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THE ADVANCEMENT OF ELECTRIC VEHICLES – CASE: TESLA MOTORS

Disruptive technology requiring systemic innovating

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ABSTRACT

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Electric vehicles have existed for over 100 years as a disruptive innovation. Even though they have always been easier to use, quieter and cleaner, gasoline cars have beaten it in price, range and faster fueling. As gasoline cars have been the technological standard for the past 150 years there has been no motivation by car manufacturers to advance electric vehicles. By producing electric vehicles Tesla Motors has appropriately become the first successful startup car manufacturer in over 100 years. This research studies the systemic innovating of electric vehicles by Tesla Motors.

Disruptive innovation is widely researched and often connected to electric vehicles. However systemic innovation has been rarely researched and none has shown that electric vehicles can be seen as one since they require significant adjustments to the business system they are embedded in to succeed as a disruptive innovation. Therefore I suggest that in certain instances a disruptive innovation requires systemic innovating. In the context of electric vehicles systemic innovating can be done on the disruptive technology level of batteries, on the finished product level of the car and on the external level of services such as charging stations.

Tesla Motors is doubling the world’s lithium-ion battery production to enable inexpensive electric vehicles. It has produced an electric vehicle platform architecture that has advantages not seen in gasoline cars. It is also creating the standard for charging stations and its battery swapping technology is providing almost instant charging. As Tesla Motors is solving the challenges of high price, low range and slow charging, at the same time it is capitalizing and building on the unique advantages electric vehicles have always had and ultimately proving electric vehicles superiority. This is largely the result of the visionary of Tesla Motor’s CEO Elon Musk who is aiming to transform the world into sustainable energy and transportation through solar panels and batteries.

TABLE OF CONTENTS

1	INTRODUCTION	5
1.1	Electric vehicles of the past	5
1.2	The case of General Motors EV1	5
1.3	Tesla Motors	8
1.4	Lessons learned	9
1.5	Research objectives and questions	10
2	DISRUPTIVE TECHNOLOGY REQUIRING SYSTEMIC INNOVATING	12
2.1	Disruptive innovation	12
2.2	Systemic innovation	12
2.3	The connection between disruptive and systemic innovation	14
2.4	Framework: Disruptive technology requiring systemic innovating	15
3	RESEARCH METHODOLOGY	23
3.1	Single case study	23
3.2	Data collection and analysis	23
3.3	Limitations.....	25
4	THE ADVANCEMENT OF ELECTRIC VEHICLES.....	27
4.1	Electric vehicles within the car industry	27
4.1.1	The advantages and disadvantages of battery motor technology	29
4.1.2	Consumers' views on cars and electric vehicles	32
4.1.3	Tesla Motors electric vehicle models and their sales	34
4.1.4	Cost calculations between electric vehicles and gasoline cars	39
4.2	Capabilities of Tesla Motors: Elon Musk.....	45
4.3	Systemic innovating by Tesla Motors	49
4.3.1	Disruptive technology level: batteries	51
4.3.2	Finished product level: electric vehicles	54
4.3.3	External level services and strategies	58
5	CONCLUSION	65
	REFERENCES	69

List of Figures

Figure 1. Five critical innovation and new product development factors (Connell et al., 2001).....	16
Figure 2. The physical levels and actors of a disruptive technology requiring systemic innovating	19
Figure 3. Comparison of technologies' business systems through time	22
Figure 4. Number of references by sub-categories.....	24
Figure 5. Power train technologies in cars and the electrification path (modified from BCG 2009.)	28
Figure 6. Tesla Motors yearly sales per unit and vehicle prices (adapted from: Loveday 2014)	34
Figure 7. Price gap between gasoline and electricity in different countries. Based on Model S and Toyota Camry after 10,000 miles of driving. (Adapted from: Loveday 2014.)	40
Figure 8. The organizational system of Elon Musk: interconnections between the companies	47
Figure 9. Systemic innovating timeline of Tesla Motors	50
Figure 10. Customers of Tesla's battery gigafactory. Musk's other companies as future and potential customers of its batteries	53

List of Tables

Table 1. Costs of usage comparison after 120,000 miles in United States and Norway	42
Table 2. Costs of owning a vehicle after 120,000 miles in United States and Norway .	44

List of Pictures

Picture 1. General Motors EV1	6
Picture 2. Tesla Motors Model S and Roadster	9
Picture 3. The Reveal Event of Model X in 2012. Elon Musk entering inside the vehicle through its gulf-wing doors	37
Picture 4. Battery pack evolution from Roadster to Model S.....	55
Picture 5. Tesla Store in United Kingdom.....	62

1 INTRODUCTION

1.1 Electric vehicles of the past

The electric vehicle (EV) is not a new phenomenon. Guarnieri (2012) writes that at the beginning of cars in 1900, battery motor was competing with gasoline engine and steam engine to discover the best replacement for the horse drawn carriage. Initially EVs had a fairly successful run alongside with gasoline cars. They even experienced what is called the golden age of EVs from 1900 to 1912. At the end of the golden age there were approximately 30,000 EVs on the roads. The height of EVs was short lived: In joint with Henry Ford's model T in 1908, findings of large petroleum reserves and regular cars beating the EV in speed, range and price, the EV industry was dead in 1930. (Guarnieri 2012).

Even though the EV quickly faded away, it had some favorable and unique qualities over normal cars. According to Schiffer (2000) gasoline cars were dirty, smelly, hard to start and expensive to operate, while EVs were clean, quiet, reliable, easy to start and simple to operate. In the height of EVs, women were especially drawn to EVs because of its clean and quiet attributes. Westbrook (2001) says that years from 1930 to 1990 can be seen as the middle years. Either the production of electric cars didn't exist or they had lousy performance numbers.

1.2 The case of General Motors EV1

Before going deeper into the case of Tesla Motors (Tesla), I will review one of the more controversial and successful efforts in electric vehicles since the golden age. In 1996 General Motors came out with General Motor's (GM) EV1. It was the first electric car built from the ground up and mass-produced by a major automaker (Adler 1996). What makes this EV1 additionally interesting is that ultimately in 2003 General Motors decided to recall all of its released EV1s from the public and destroy them. Even Tesla Chief Executive Officer (CEO) Elon Musk thought that after GM EV1 there would have been EV2 and EV3 and so forth (Teslive 2014.) Taking a look

into its story will help in creating the larger context of EVs and help in understanding the case of Tesla Motors better. Picture 1 is of the EV1. It was a two-seated coupe with a unique design. EV1 had a range of 100 miles and was initially priced at 33,000 dollars.



Picture 1 General Motors EV1

Brian Johnson (1999) writes about EV1's creation. The prototype of EV1 was called Impact. In 1990, California Air Resources Board (CARB) had been looking for years for an answer to California's pollution problems. With Impact, CARB felt they had found a solution. Thereafter CARB passed its zero-emission vehicle (ZEV) mandate. The mandate required California's top seven automakers to produce a minimum of two percent of EVs by 1998 and ten percent by 2003. CARB wished that the technology forcing mechanism would work, without realizing that Impact was merely a prototype model.

After the Impact prototype, a "PrEView Program" was set up to find out if the general public had an interest in the EV. The program enlisted ads in newspapers to find willing testers for a two week test run of the Impact. The interest in the program

was immense. After Los Angeles received 10,000 calls and New York received 14,000 calls they had to cut the lines. When the public was done with their test runs on the Impact, nearly all of the testers fell in love with it and wanted to prolong the testing period. (Johnson 1999.)

In 1996 at a Los Angeles auto show GM came out with Impact that had been renamed EV1. In the auto show GM CEO Jack Smith announced: "This coming fall, General Motors will be the first major automaker in modern times to market specifically designed electric cars to the public. We have the assembly plant tooled. We have the distribution system ready. We have the markets identified. And we have the automobile. This is not a concept car. This is not a conversion. It is a car for people who never want to go to the gas station again. It is even more important as the first product in a portfolio of high technology products that we will be bringing to the market in the years ahead. These are products that will define the GM of the future." GM even named EV1 directly under GM with "General Motors EV1". This demonstrated GM's will to change its image and EV1 was to be the showpiece of this change. (Johnson 1999.)

The production version of EV1 was received positively. Motor Trend (1996) reviewed it by saying: "The Impact is precisely one of those occasions where GM proves beyond any doubt that it knows how to build fantastic automobiles. This is the world's only electric vehicle that drives like a real car." It was the most aerodynamic production car ever built. It even broke the land speed record for production electric vehicles of 183 miles per hour. (Vauxhall 2001). The reason GM could in the end recall and destroy each EV1 was because they decided only to lease the cars to customers. All 1,150 of them were destroyed in 2003, except one intact EV1 that was donated to the Smithsonian Institution. (Hovis 2013).

The destruction of EV generated a lot of controversy. In 2006 it ended up in a documentary movie "Who killed the electric car". The movie had a sentimental tone towards the car and EV1 owners praising its qualities. Critics of GM and proponents of electric vehicles claim that GM feared the emergence of electrical vehicle technology because the cars might cut into their profitable spare parts market,

as electric cars have far fewer moving parts than gasoline motors. Critics further charged that when CARB, in response to the EV1, mandated that electric vehicles make up a certain percentage of all automakers' sales, GM came to fear that the EV1 might encourage unwanted regulation in other states too. GM eventually battled against CARB regulations, going as far as to sue CARB in federal court. (Who killed the electric car 2006.)

Nevertheless in 2010 GM started producing a plug-in hybrid called Chevrolet Volt. Interestingly in 2013 GM assembled an internal taskforce called “Tesla Team” to investigate Tesla’s actions and the reasons for their success. GM Vice Chairman Steve Girsky said Tesla was “revolutionizing the business model -- not just how you put an EV together but how you go to market with something like this.” (Klayman 2013.)

1.3 Tesla Motors

Tesla Motors was found in 2003, the same year EV1 was destruct. It is a car company that produces only electric vehicles. It is the first successful startup car manufacturer in over 100 years (Baer 2014). It released its first EV in 2008, a two-seater sports car called Roadster. It was actually the first production car to use lithium-ion batteries, the first to be able to travel over 200 miles (244 miles) and it made the world distance record of 311 miles. Even though Roadster was priced at 109,000 dollars, it proved to the public that an EV could be fast and have a long range.

In 2012 Tesla released Model S, a seven-seated EV that competes in the premium sedan category. Unlike the Roadster, Model S was created entirely by Tesla (Welch 2014). Its prices range from 58,570 dollars to 106,900 dollars, with driving ranges from 208 to 265 miles. Picture 2 is of the Tesla Motors Model S and the Roadster. Model S is the sedan on the left and Roadster the convertible on the right. Model S proved what EVs are truly capable of.



Picture 2 Tesla Motors Model S and Roadster

Model S has won awards such as the 2013 World Green Car of the Year, 2013 Motor Trend Car of the Year, Automobile Magazine's 2013 Car of the Year, Time Magazine Best 25 Inventions of the Year 2012 award and Consumer Reports called it “the best car ever tested.” Model S is one of just a few cars to have ever achieved a 5-star safety rating from both Euro NCAP and the U.S. National Highway Traffic Safety Administration (NHTSA).

1.4 Lessons learned

Going back to the case of GM EV1, GM spokesman Dave Barthmuss explained GM’s reasoning for dropping the EV1 program: “After spending over one billion dollars on the development of EV1, we were only able to lease 1,150 of them. If we’re really going to make a difference in environmental auto issues, we have to be able to see vehicles in the hundreds of thousands of units, instead of hundreds.” (Schneider 2005.)

In my opinion GM failed and Tesla is succeeding because if a company wants to advance EVs, it cannot do it by using and exploiting the old business system of gasoline cars. Instead they need to create a completely new business system around the EVs and innovate all of the different areas that need improving, such as charging stations. Answering to this need is called in this research as the systemic innovating of EVs which is based on the relevant theory of systemic innovation that will be presented in the theory chapter. Tesla is trying to successfully implement systemic innovating. The main difficulty with this objective is that the business system of gasoline cars has been innovated and advanced for the past 150 years and counting.

To highlight these systemic needs of EVs, “Who killed the electric car” (2006) noted that at the time of EV1 the state of California required car manufacturers to maintain a parts supply and service infrastructure for a minimum of 15 years after a car was introduced to the market. EV1 would not only have required its own supply of parts and maintenance, but to fully utilize its potential, EV’s disadvantages such as high price, low range and different recharging solutions would have needed attention. Tesla is proving its willingness to invest on EVs in the long-term.

Musk said in an interview (RTL Z 2014) that all of the proceeds the company receives from its current EVs will be placed into the development of its future models. Even with the complex advancing requirements of EVs, Tesla still made a revenue of 2.5 billion dollars in 2013 and Morgan Stanley expects the revenue to be ten-fold by 2016 (Sharf 2014). Although today the electric car industry is just a drop in the ocean for the whole car industry, are we seeing Tesla initiating the ripple effect towards the new golden age of electric vehicles?

1.5 Research objectives and questions

The first objective of this research:

- *Build a theory framework to understand how a leading company does systemic innovating on a disruptive technology.*

The resulting research questions:

- *How is Tesla Motors implementing systemic innovating of electric vehicles?*

The framework will be covered in the next chapter of this research. It will be based on relevant theories of disruptive innovation and systemic innovation and aims to find new ground for these previously separated theories. Additionally there are relevant theories related to the adoption of new technology and capabilities of a company to innovate. In the methodology chapter I will display the dualistic nature of this research: it is aiming at the same understand the large, complex and intertwined case of Tesla, connect it to relevant theories and try to find new theories in relation to the case and relevant theories. In the research chapter I will show the disadvantages and advantages of battery technology, how consumers view cars and EVs, what are the different costs related to EVs and present the findings on how Tesla has implemented systemic innovating. In the conclusion chapter I will try to present the important implications for theory and practice of this research.

2 DISRUPTIVE TECHNOLOGY REQUIRING SYSTEMIC INNOVATING

2.1 Disruptive innovation

Disruptive innovation is a term coined by Christensen (1997). A disruptive innovation is a new product that underperforms with its primary performance dimension, which is most appreciated by the mainstream customer. Nevertheless it outperforms the old product in a new performance dimension and finds a new market for itself. The new product could be easier to use or have a lower cost. With time the new product will improve also on the primary performance dimension and eventually grow to dominate the market. (Christensen 1997).

Christensen's work has also received critique and efforts to clarify the term further. Markides (2006) sees that Christensen's term has been wrongly used to explain all kinds of disruptive innovations. Originally the term was proposed to describe technological innovations, but in the end Christensen decided to put technological innovation, business model innovation and product innovation together under the term of disruptive innovation. These different innovations cannot be seen as one since they create different kind of markets, pose different challenges for established companies and have radically different implications for managers. Previous literature finds that a disruptive innovation does not have to be so extreme. It might capture a certain percentage of the market but not necessarily overtake the traditional competition completely. (Markides 2006.)

2.2 Systemic innovation

Before going into systemic innovation, it should be stated what is meant by a system. Ackoff (1973) explains a system to be a set of two or more interdependent elements, in which each element has an effect on the behavior of the whole. It is an indivisible whole that loses its properties if it is taken apart. The elements of the

system may be systems themselves and every system may be a part of a larger system. In general, changes in one part affect other parts.

Systemic properties in innovations have been subject to very limited discussion within literature (Maula, Keil & Salmenkaita 2006). Chesbrough and Teece (1996) are one of the more noted systemic innovation researchers. According to them the easiest innovations to pursue are autonomous. Autonomous innovations can succeed with their own merits. When an innovation cannot succeed on its own merits, the innovation is systemic: its benefits and success can be met after other complementary innovations are created. (Chesbrough & Teece 1996). Maula et al. (2006) say that systemic innovation is an innovation that requires significant adjustments in other parts of the business system they are embedded in. Therefore it does not include only innovations.

Autonomous innovation can be quite easily managed by one company, but often systemic innovations require additional external innovators. These external innovators take part in the business system by adding their own contribution to it for the core innovation to succeed. Systemic innovation requires information sharing and co-ordinated adjustment throughout an entire product system. Therefore it should be done in an integrated fashion within one company, rather than across company borders. This way arising conflicts can be avoided as the systemic innovation develops. (Chesbrough & Teece 1996.)

Maula et. al. (2006) finds Chesbrough and Teece's (1996) advice especially difficult in complex systems: "While integrating systemic innovation economizes on the cost of coordination and provides control benefits, it is frequently infeasible since even the largest firms lack the financial resources let alone technological and market capabilities to create the simultaneous complementary innovations necessary for successful systemic innovation". The process of innovating in a systemic fashion is mentioned in this research as systemic innovating.

The proposed methods of resource allocation differ for disruptive innovation and systemic innovation. In the case of disruptive innovation, Christensen (1997)

proposed that incumbent companies should separate the resource allocation for the disruptive technology from the incumbent one. This way both technologies through internal resource allocation will have their own space to explore and grow. Maula et. al. (2006) found this not to be true with systemic innovation where the resource decisions of external actors is additionally important.

2.3 The connection between disruptive and systemic innovation

Maula et. al. (2006) notice only the differences of resource allocation between disruptive and systemic innovation. I suggest that in certain instances an innovation can be seen to have strong elements of disruptive and systemic innovation. In practice this means that while the innovation can capture some percentage of the market even without systemic innovating, it cannot compete against the incumbent technology on the most important performance dimensions without significant adjustments to the business system it is embedded in. Without these adjustments the innovation cannot succeed as a disruptive innovation. In these cases the disruptive technology is part of the systemic innovating and therefore there should not be a separation on the method of resource allocation. While there is little research done on systemic innovation, there is no literature about the possible interconnection between the two theories.

The connection can be found from the description of disruptive innovation. According to Christensen (1997) a disruptive innovation underperforms against the incumbent technology on the primary performance dimension, but outperforms on a new one. Then the disruptive technology will advance enough to perform at the same level on the primary performance dimension, while still outperforming on the new dimension. Thereafter it would capture the incumbent market. (Christensen 1997.) In the context of systemic innovation, I see that the disruptive innovation might also succeed to capture a certain percentage of the market with its new performance dimension, but capturing a larger percentage of the market would require systemic innovating. The innovation requires adjustments and innovations not only to the product, but also to the larger context of business system that defines some of the products' many performance dimensions.

2.4 Framework: Disruptive technology requiring systemic innovating

Disruptive technology is always competing against the incumbent technology. It is decided by the consumer if the new technology is desirable enough to buy. In the context of disruptive technology requiring systemic innovating, the challenge is not only about advancing the product, but advancing the business system as a whole to unlock the innovation's true potential. Again it will be decided by the consumer if the innovations and adjustments within the business system make the product competitive enough for consumers to buy it.

This theory structure can be summarized by:

- *As the combination of capabilities of the disruptive technology and the leading company to do systemic innovating in a way that satisfies customers' needs over the incumbent technology and its business system*

First the core capabilities or advantages and disadvantages of disruptive technology should be assessed. This demonstrates the products' competitiveness without systemic innovating. As the theory of disruptive innovation suggests, it does not have to overtake the market completely, so the core advantages of the technology might be sufficient enough for it to control a part of the market.

Also it is important to measure the capabilities of a leading company to produce a disruptive product and capitalize on its advantages and solve its disadvantages. Maula et al. (2006) highlight and have studied the proactive management of systemic innovation in industry leading companies. With disruptive innovation a leading company displays the true potential of a product. Therefore the capability of a leading company to innovate becomes in question. Maula et al. (2006) see that since systemic innovation requires the simultaneous development of multiple

complementary innovations, the implementing of systemic innovating is often demanding for industry leaders.

Five critical innovation factors

To understand a leading company's capabilities to innovate, Connel, Edgar, Olex, Scholl, Shulman and Tietjen (2001) have found five critical success factors for innovations. Figure 1 show their framework and the five critical innovating factors: executive direction, project team, innovation strategies, internal factors and external factors. These layers can vary in size. The bigger the layer, the more successful that part of the innovating effort is. The sizes of each layer affect the total size of the pyramid that measures the total success of the innovation and new product development. The vertical line on top of the pyramid represents the edge of success. If the pyramid rises above it, the product is successful, if it stays below it, it is a failure. Even if several of the layers are weaker than average, one individual layer might compensate by a "heroic effort" towards success. (Connell et al., 2001.)

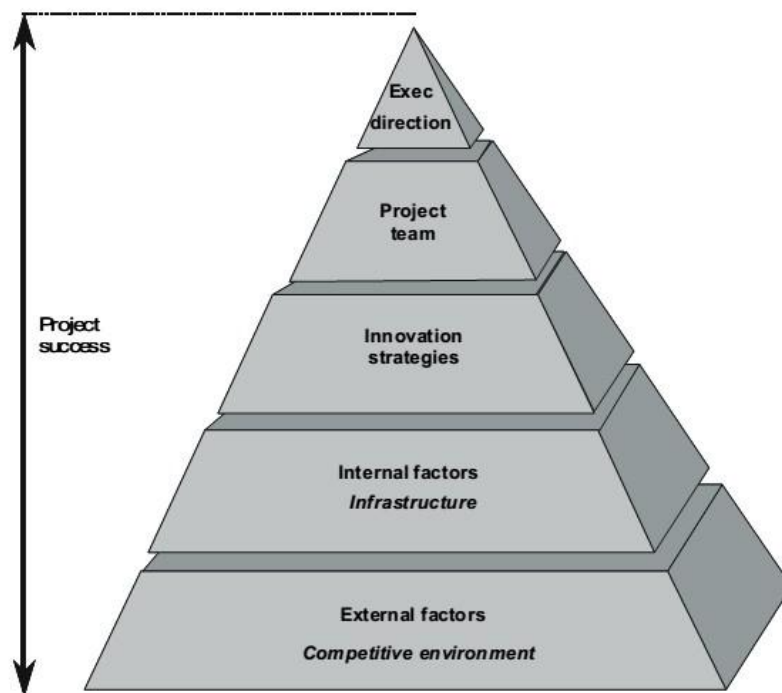


Figure 1 Five critical innovation and new product development factors (Connell et al., 2001)

The description for the five layers (Connel et. al. 2001):

1. Executive Direction: Top management support and participation. The company leaders need to take an interest in the project and support his teams by securing necessary funding and other resources. They need to set the objective in broad terms and follow his teams functioning as intended.
2. Project Team: Cross-functionality is the key. People with different backgrounds and skills will benefit the team's effectiveness. Also the team needs sufficient knowledge, skills and abilities.
3. Innovation Strategies: The team needs to match their approach to the situation at hand. Different strategies are needed for different innovation types.
4. Internal Factors (infrastructure): "Internal factors can make or break an innovation effort. The correct internal infrastructure includes having an appropriate organizational design, using the right team structure (e.g., Matrix, Hierarchical, and Skunkworks), employing the correct team composition (the right personnel), capturing and using organizational knowledge, and implementing operational and managerial policies and procedures that stimulate innovation that include ways to secure the needed capital resources."
5. External Factors (competitive environment): Divided into Remote, Industry or Company factors. Remote factors include economic, regulatory, social, political and ecological variables that are beyond the borders of the company. Industry factors represent competition and the supply chain, over which the company has only a limited control. Company factors are the operational components of a business over which it has the most influence, as in customers, competitive position and creditors.

Consumers' motivational dimensions in adopting new technology

After understanding the capabilities of the technology and the leading company, it is important to understand how consumers decide whether they want to adopt the new technology. Foxall et al. (1998) found that the tendency of customers to adopt new technologies is linked to consumers' innovativeness. According to Dittmar (1992) the consumers' innovativeness depends on three motivational dimensions: instrumental, hedonic and symbolic. Instrumental attributes refer to the functionality of the new technology: how practical and beneficial it is to use. Hedonic attributes refer to the emotional experience achieved from the use of the new technology, such as joy or pleasure. Symbolic attributes are related to a sense of self or social identity and whether the adoption of new technologies reflects these attributes. (Dittmar 1992.) Therefore the three motivational dimensions help in identifying if the disruptive technology has high enough instrumental, hedonic and symbolic attributes for people to buy it.

The physical levels of a disruptive technology requiring systemic innovating

I have built a framework to understand the physical dimensions of disruptive technology requiring systemic innovating and its actors. This framework is shown in Figure 2 and it has three levels. The core level is the disruptive technology itself. Second is the finished product level that has the disruptive technology within it. Last is the external level that is outside of the product itself, which includes products and services that support the core product. All of the levels represent where an innovation or adjustment is located, and all of these should reflect the needs and requirements of the consumers. The framework shows also the actors of the business system that execute systemic innovating either directly or indirectly.

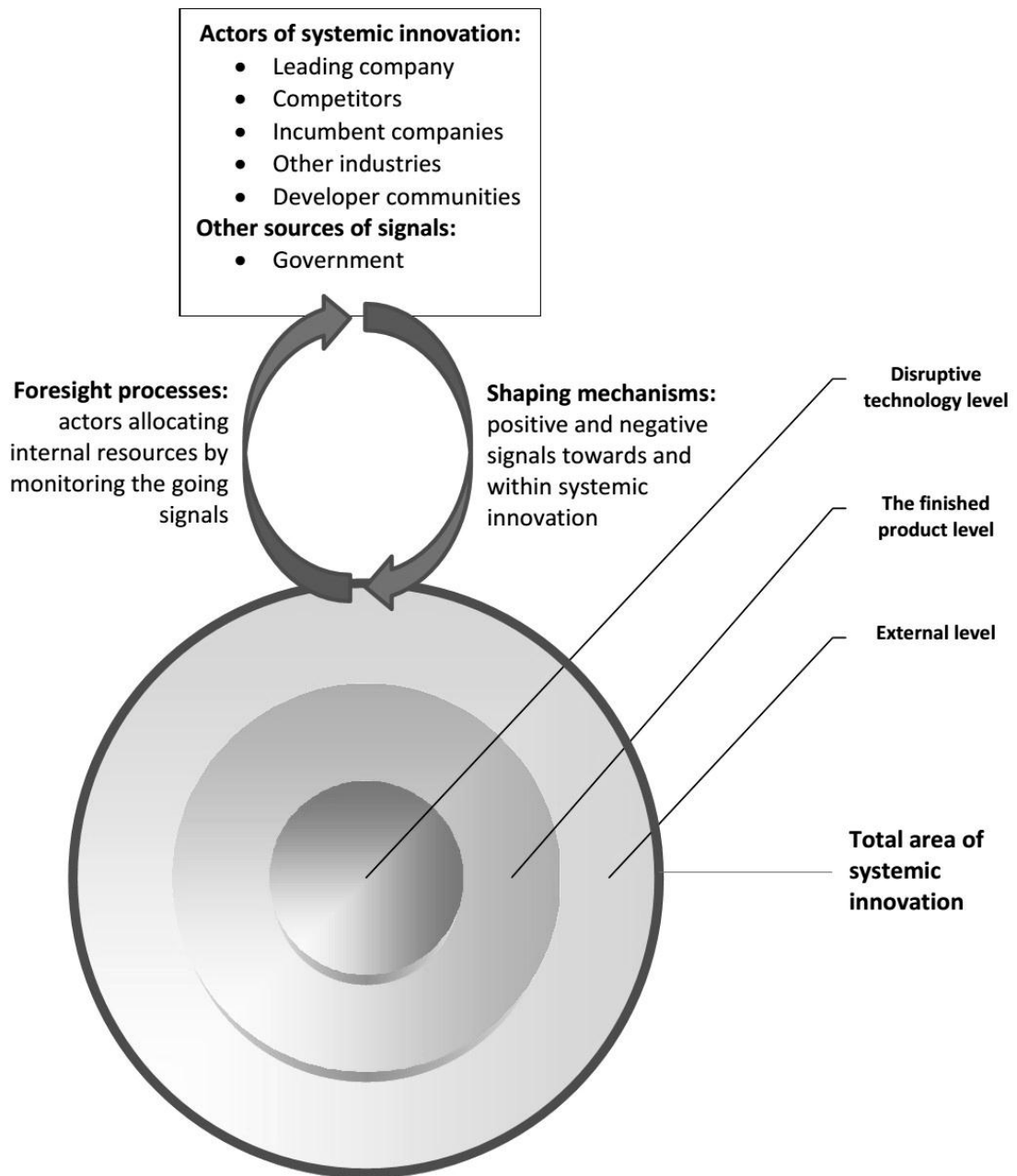


Figure 2 The physical levels and actors of a disruptive technology requiring systemic innovating

The three physical levels of Figure 2 are simplistic, but there are three key reasons why:

1. System itself can be such a large concept that it shouldn't be partitioned into excessively small portions.
2. The framework functions as a comparison tool between the disruptive and

incumbent technologies. Therefore the framework needs to highlight also the levels of incumbent technology's business system.

- 3.** It reveals on a basic level how disruptive technology is part of systemic innovation. This is important because of the lack of research on the connections between the two theories.

The framework has some complementary structures from the research of Maula et al. (2006) and Chesbrough (2003) on systemic innovation. Figure 2 shows what Maula et al. (2006) call the actors of systemic innovation. This includes the leading company, competitors, incumbent companies, other industries, developer communities and governments. They are the ones that are connected to the disruptive technology's business system and their direct or indirect actions affect it either positively or negatively.

Chesbrough (2003) refers to this as the action-reaction method of a systemic innovation. When one actor acts towards it, other actors react to it. This cycle of actions and reactions is seen in Figure 2 as what Maula et al. (2006) refer to the shaping mechanisms and foresight processes of systemic innovation. With shaping processes the actors want to influence the evolution of technologies and markets and the resource decisions of others in the environment. With foresight processes the actors monitor the development of multiple simultaneous innovations and adjust their internal resource allocation accordingly. With their internal resource allocation, the actors form the total pool of resources that flow in and out of the business system.

Maula et. al. (2006) see that systemic innovation requires not only the allocation of internal company resources such as workforce, machinery and funds, but also the external allocation of resources of actors such as partners and developer communities. Therefore a company committed to the core technology has to keep the external actors committed to its systemic innovation. This requires a willingness to communicate forwardly between the companies and benefits from open exchange of ideas and resources. (Maula et. al. 2006). Chesbrough (2003) refers to this as open innovation, meaning the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation,

respectively.

Since systemic innovation requires the simultaneous development of multiple complementary innovations, business systems often require leadership by a small group of firms that can function as anchors for coordination (Maula et al. 2006). Chesbrough (2003) calls these architects. Maula et. al. (2006) add: “They (architects) provide leadership to a systemic innovation by establishing the system architecture, communicating it, and enabling others to support and further develop it. The architect stands to gain significantly from the innovation since they frequently produce important components of the systemic innovation or play a central role in its commercialization.”

According to Chesbrough (2003) the external actors always analyze the level of commitment the leading company has in systemic innovation. Especially when the leading company produces an architectural standard, this is a sign of a high level of commitment. On the other hand if the incumbent companies do not believe in the success of the disruptive technology and don't see it as a threat, they won't allocate resources into it. This is a clear negative signal towards the systemic innovation.

One important factor of the framework to take into account is that some actors might not directly advance the systemic innovation. Actors such as developers or other industries might develop technologies or products that are not directly targeted to the disruptive innovation, but nevertheless their actions help in advancing some parts of the business system. (Maula et. al. 2006.) For example when mobile phones entered the mass market in 1990's and disrupted the market of landline calls, satellites were orbiting the earth decades before the commercialization of mobile phones. Maula et. al. (2006) also found that policy actors may play an increasingly important role in stimulating innovative activity to a systemic innovation.

Comparison of technologies' business systems through time

According to Maula et al. (2006) a leading company doing systemic innovating needs to explore and manage different time frames. With the addition of disruptive technology, its business system is compared to the business system of incumbent

technology. Figure 3 illustrates this comparison between the disruptive and incumbent technologies' business systems over a period of time. The disruptive technology does not exist at the first point in time where the circles are dotted, while at the second point in time it does. It also illustrates in a simplistic manner that both business systems grow through time, but the disruptive technology's business system stays smaller and less competitive at both stages.

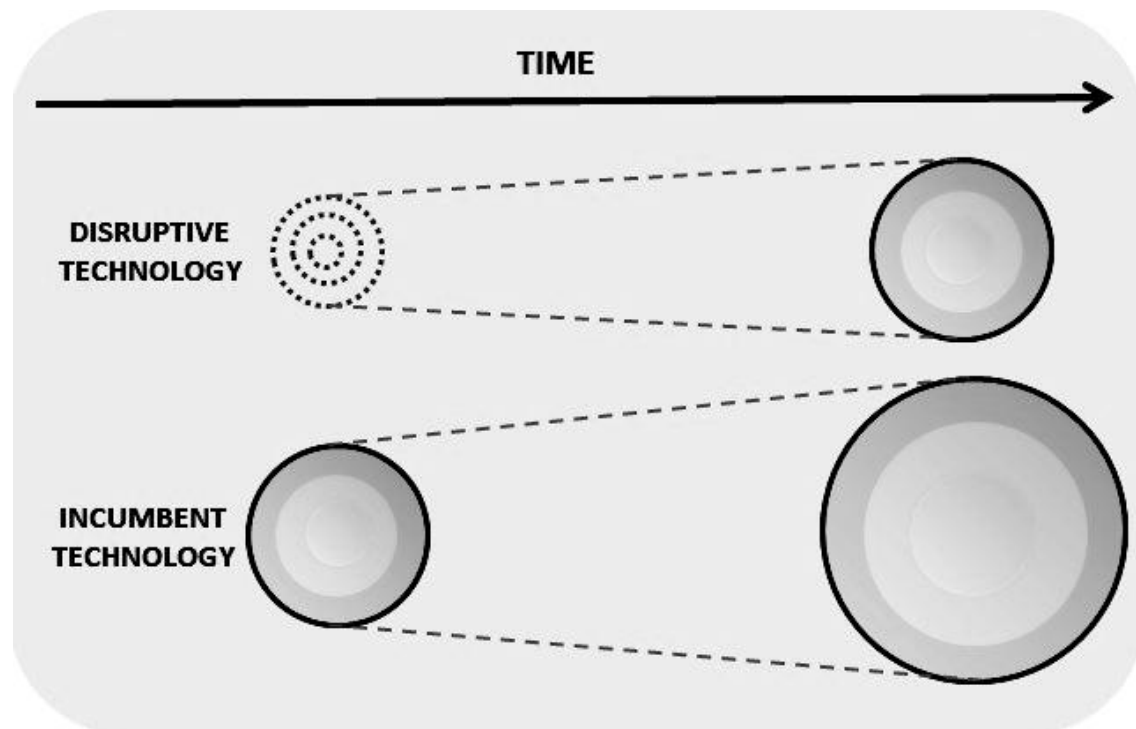


Figure 3 Comparison of technologies' business systems through time

Since disruptive technology competes with the same performance dimensions as the incumbent technology, the disruptive technology could be able to capitalize on some of the incumbent technology's business systems' functions. This can be demonstrated with the emergence of smartphones. From their inception, smartphones have begun to dominate the mobile phone market with its performance dimension of a large touch-screen. Nevertheless it fitted mostly to the old mobile phones' business system regarding the way communication technology works on the finished product and external levels. Even though it didn't require systemic innovating to succeed, it demonstrates how comprehensively a disruptive innovation can capitalize on the business system of the old product.

3 RESEARCH METHODOLOGY

3.1 Single case study

It is common for a qualitative research focusing on business to have only one or two cases. This enables the researcher to create a reliable and rich description of the cases. Focusing only on one case can be justifiable if the description is tied to scientific discourse (Koskinen, Alasuutari & Peltonen 2005.) Even though the advancement of EVs' business system can be seen as the effort of all of the related actors, a leading company such as Tesla has produced the most disruptive products. Therefore because of the disruptive nature of Tesla's market leading EVs and the unwillingness of leading companies to invest in them lead me to focus mainly on the efforts of Tesla. Also the justifiability to use only Tesla related to the strong theory focus it revealed and was eventually used in this research.

This research is both an instrumental and a descriptive case study. According to Eriksson and Koistinen (2005) the instrumental case study should be chosen when the case has an instrumental role of revealing through it something additional. In my view the case of Tesla is important by itself, but instrumentally it helped in finding its relevant theories and in contributing to new theory. Eriksson and Koistinen (2005) see that a descriptive case study includes the understanding of processes and its different events and stages. In a descriptive case study the theory is useful if it helps in producing a valid explanation for the case. If the theory does not explain the case and its process as such, it should be re-designed or developed further by the researcher. This way the formed theory could be applied to other studies. (Eriksson & Koistinen 2005.) The challenge with Tesla was that the advancement of EVs is a large, complex and intertwined process. As I tried to understand the case comprehensively, at the same time I had to continuously reflect between the material and its relevant theories. As the research process went further I found that the relevant theories could not explain the case of Tesla as such, therefore I had to develop them further and re-

design them to fit into the case of Tesla.

3.2 Data collection and analysis

According to Eriksson and Kovalainen (2008) a qualitative content analysis is done first by dividing the content into numerous different pieces, than by conceptualizing it and finally by structuring a new kind of whole. Tesla has been especially visible in the media. These included different news articles, Tesla's events, website and blogs and interviews with Elon Musk. Especially Musk's statements throughout media had a large role in this research. They functioned as commentary as the material regarding Tesla communicated with the related theories. Figure 4 shows the different sources of references for this research. There were 79 other, 26 literature and 20 Tesla Motors references. Other references included mostly internet sources, literature included books and journals and Tesla Motors included internet sources produced by Tesla, such as blogs and events. Especially the internet sources highlighted the complexity of this case. From the dispersed information I had to focus to the most essential data and structure it into an understandable whole.

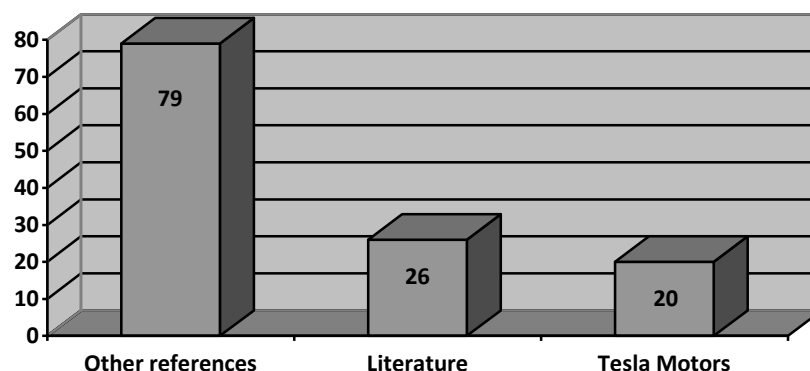


Figure 4 Number of references by sub-categories

I have used qualitative content analysis in studying Tesla since according to Tuomi and Sarajärvi (2002) through it qualitative content can be systematically organized and analyzed. Qualitative content analysis aims to understand the subject through

categorizing or choosing themes from the content. This can be done with the content-oriented, the theory-guided or the theory-oriented method. The content-oriented method means that the theory will be built based on the content. This method of inductive analysis means moving from singular observations into generalizations. Theory-oriented method is the opposite and used when the analyzing of the research material is based on an existing theory or model. The existing theory or model will be tested in a new context. The method of analysis is deductive which means moving from general to singular observations. Theory-guided is a method between the other two in which the abductive analysis of the material is not solely based on theory, but the connections to it can be seen. In addition to the findings from the material itself, theories will help in explaining and validating the findings. Additionally a researcher can make findings on the material that contradict what previous research has found. (Tuomi & Sarajärvi 2002.)

This research was theory-guided since it has both content-oriented and theory-oriented elements in it. First I began by understanding the case of Tesla as comprehensively as possible to understand what theories are most related to it. Thereafter I found that since it is largely based on existing theories of disruptive and systemic innovation, the research began to have theory-oriented elements. On the other hand the theories separately as such could not explain the phenomenon of Tesla and that is why I had to use the findings on the material to build new theory that would contradict with some of the previous findings on these theories. This explains the content-oriented elements which ultimately led me to choose the theory-guided method.

3.3 Limitations

Considering this research's background in management, managers need to be able to master multiple areas in relation to a company. Therefore as the focus of this research was wide, at the same time no particular area of the research was examined in an in-depth manner. Nevertheless the wide focus was a requisite since all of the parts were connected to each other and created a larger whole - as a system does. In practice this meant that when I found more literature regarding how Tesla had advanced EVs, at

the same time I began understanding what the larger implications of this would be.

I believe one of the limiting factors regarding this research was the important use of the term “system”. Since system can be seen as a large whole with interconnecting parts, also the gathered data needed to reflect how the parts were connected. Additionally the focus was to find aspects that showed both systemic and innovative attributes. According Maula et al. (2006), adjustments in a business system are needed for systemic innovation, but some of the smaller adjustments were left out of the research if they did not contain enough of systemic or innovative elements.

One of the challenges in focusing mainly on Tesla was the fact that I did not have any access to Tesla as a company. As the theory suggests, a company’s capability to innovate depends on five factors. Especially the pyramid framework’s levels of “project teams” and “internal factors” were difficult to include into the research without direct access to this information. Also as Tesla is such a new company, the previous research done on it is limited. The main focus used in this research regarding the innovation factors, was Tesla’s CEO Musk. Regarding the focus of management in this research, it seemed fitting to examine what has been the role of Musk in Tesla’s success. Understanding Musk helped me in understanding Tesla’s actions thus far.

Even though Musk can be seen as one of the most knowledgeable person in EVs, some of his statements could be biased towards getting more attention or sales for Tesla. Also some of the representatives of media could have pro-environmental traits and see some of the efforts of Tesla more positively than others. Therefore I had to focus on constructing the most objective data regarding Tesla. I have aimed to both gather and analyze data conservatively as not to give a too optimistic assessment of Tesla’s efforts.

4 THE ADVANCEMENT OF ELECTRIC VEHICLES

In this main chapter I will use the theory structure to highlight what Tesla has done so far. First I will give more general information about EVs, such as the core advantages and disadvantages of the technology and how consumers relate to cars and EVs. Second I will describe Musk's role in Tesla's success as the company's CEO and show the larger context of a beneficial system that his three companies create with their connections to Tesla. Last I will describe Tesla's systemic innovating. In relation to the theory structure, the research chapter of this research can be summarized *as the combination of capabilities of the battery technology and Tesla to do systemic innovating in a way that satisfies customers' needs over the gasoline car and its business system.*

4.1 Electric vehicles within the car industry

In this chapter I will give more general information related to EVs. First I will show how EVs fit into the car market today. Second I will show the consumers' perceptions about EVs and cars in general. Third I will describe what are the advantages and disadvantages of EVs in comparison to gasoline cars, without Tesla's systemic innovating. Last I will present Tesla's current and future models of EVs and the cost comparison of owning and using a Model S compared to a gasoline car.

Defining the market

Figure 4 represents the different possible power train technologies in a car today and its electrification path. The first three powertrains depend mainly on a gasoline engine, whereas the last three have a plug-in capability for batteries. In United States there were 16.5 million cars sold in 2014. Of these, 119,710 had the plug-in capability. (Geier 2015.) There are going to be 15 new car models in 2015 that have the plug-in capability (Zach 2014).

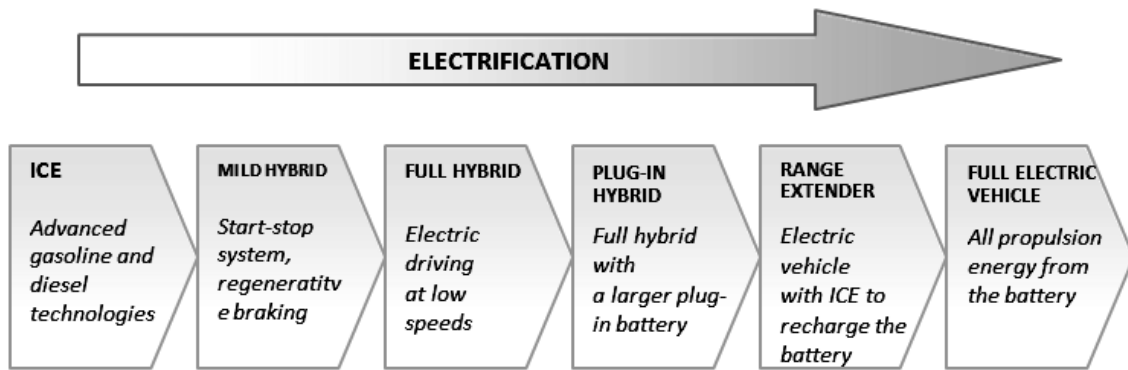


Figure 5 Power train technologies in cars and the electrification path (modified from BCG 2009.)

In United States full electric vehicle sales increased by 58 percent from 2013 and amounted to 44,913 (Zach 2014). Tesla produced approximately half of the sold EVs in 2013. In February 2015 Tesla sold 2,000 Model S' and was the most sold EV. Nissan Leaf (29,010 dollars) came in second with 1,198 and BMW i3 (41,350 dollars) third with 1,089. The rest, such as Chevrolet Volt (34,345 dollars) had much weaker sales numbers (Shahan 2015.) Nissan Leaf is a full electric vehicle, while BMW i3 and Chevrolet Volt are plug-in hybrids.

Toyota Prius is a full hybrid vehicle. Its 2013 model has a fuel economy of 48 miles per gallon, while Environmental Protection Agency (2014) estimates that a 2013 production year car in United States has a fuel economy of 23 miles per gallon. With such an excellent fuel economy it is easy to see why Prius has been so popular. According to Tuttle (2015) Toyota sold 207,372 Prius' in 2014, but it represented an 11.5 percent decrease from 2013. He adds that all full hybrid vehicles had a 9 percent drop in their 2014 sales compared to 2013.

Elon Musk discussed the future of cars in a GTM TV (2010) interview. He sees that "hybrids are like amphibians. In the transition from oceans to lands, there were initially a lot of amphibians. There is a medium-term role in plug-in hybrids, but in our view not a long-term role". Musk feels that in the long term all cars will become electric. He added that the only reason why we would need gasoline engines is "if the battery pack does not have enough range, if the recharge times are really slow or if there is no battery pack swap infrastructure, and all of those problems are getting

solved”. He feels that the goal of Tesla is to try to bring the future closer sooner and hopes that Tesla will help accelerate this transition by five or ten years.

4.1.1 The advantages and disadvantages of battery motor technology

In this chapter I will disclose the advantages and disadvantages of battery motors compared to gasoline engines. It will be an in depth analysis of the technologies that will corroborate the findings in next chapter, of the consumers’ drivers and barriers of adoption of EVs. This comparison of technologies includes mostly the core advantages and disadvantages of battery motor technology, but includes only a few advantages achieved by Tesla. Later in the systemic innovation chapter I will present findings on how Tesla has capitalized on the technology’s advantages and how it has solved its disadvantages.

Advantages

Even though EVs are zero emission vehicles, they can still produce pollution through their manufacturing. According to Schuitema, Anable, Skippon and Kinnear (2013) their polluting depends additionally on the carbon intensity of electricity generation, the ratio of urban to extra-urban driving undertaken and even on the time of day when recharging occurs. Powering EVs using electricity generated from burning coal is clearly not the most efficient way. Nevertheless, Boston Consulting Group (2010) have found that electric cars’ total emission advantage from production to usage is 40 to 60 percent. In 2020 it they estimate it to be 30 to 50 percent as combustion engine technology advances and narrow the gap.

According to a study by Loveday (2014), the price gap between gasoline and electricity in different countries after driving a gasoline car and an EV for 10,000 miles was cheaper for EV even in a country such as Saudi-Arabia where according to Global Petrol Prices (4th of May 2015) the price of gasoline is the third cheapest in the world. Tesla’s EVs are still quite expensive, but as their prices drop and performance enhances, the total cost benefits become larger for EVs. Later I will show the price gap list and also do a calculation on the running costs and owning costs of Model S compared to a gasoline car.

According to Tesla, Model S motor has only one moving part, while a gas motor has hundreds. Therefore there are fewer things that can go wrong in Model S compared to a regular car. (Tesla Motors Facebook post 2013.) EV's require less maintenance since there are no oil changes or other moving parts in need of regular checkups. The only sound you will hear from the motor is a slight hissing sound, which makes traveling more comfortable. There is no transmission and the electric motor also delivers the same torque at any speed without gear shifting, which makes its acceleration smoother. EVs are also about four times more efficient in converting stored energy into kinetic energy than ICE (from batteries to the wheels). According to Tesla (Tesla Motors website: go electric) EVs are approximately three times more efficient in converting energy into motion. By their estimates only 20 to 25 percent of energy stored in gasoline actually turns the wheels.

Battery pack of an EV is in theory the same as a gasoline tank for a normal car. But with EVs, battery pack also defines the power of the vehicle. A bigger battery pack for an EV increases its range, but at the same time it increases its performance, such as torque, acceleration and top speed. Therefore a battery pack is in large part comparable to the engine of a gasoline car. But gasoline cars' engines are mostly heavy and located in one part of a car, in the front part in most cases. An EV, such as Model S, uses lithium-ion batteries, the same type of battery that goes into mobile phones and laptops. Therefore EV batteries have the advantage of small size in comparison to gasoline engines and this can be seen in the platform advantages of Model S which will be later disclosed.

Tesla wrote in its blog about their closed loop battery recycling program (Tesla Motors Blog: Tesla's Closed Loop Battery Recycling Program, 2011). According to it Tesla has been refining its battery recycling program for years. Before the battery packs are recycled Tesla reuses the case and some of the electronics, which is 10 percent in weight of the battery pack. Tesla is working with Umicore to recycle the batteries into completely reusable materials and the business is profitable.

Since 93 percent of people drive less than 100 miles a day, today's EVs eliminate some of the need for use of public charging stations. As Tesla's EVs have a much

longer range than this, in theory most of the required charging can be done at home or at work. Additionally, as the range of Tesla's EVs increase over time, the less they need to be recharged. With gasoline cars they need to be always filled at public fueling stations which takes time and is often dirty.

One additional advantage or a facilitator for entry for EVs is government involvement. To attract mainstream customers, products in energy and mobility especially require infrastructures, rules, norms and regulations (Yu & Hang 2010). Governments are often geared up towards achieving environmental goals. This would include involvement in supporting customers, manufacturers and developers towards environmental goals. Nevertheless ultimately government involvement is not a long-term solution to make EVs more enticing to customers. It might ease the transition towards increased adoption of EVs but in the long-term and on a large scale it would not be economically sensible to them.

Disadvantages

As Tesla has proved, EVs can have a long range and be fast. The downside of a long range is that it requires more batteries that are expensive and heavy. According to Tesla's Chief Technology Officer Straubel, the battery pack in Model S' makes up less than half and most cases less than a quarter of the price of a Model S and weighs approximately 550 kilograms (Bullis 2013). Tesla has only begun to produce EVs and its production numbers are nowhere near with gasoline car companies. Therefore it can't benefit from economies of scale that some of the larger gasoline car companies benefit from. Nevertheless other industries, such as laptops and mobile phones, are also driving the advancement of batteries, which might result in cheaper or more efficient technology.

Batteries lose gradually their power capacity which means that the maximum range of an EV decreases over time. Plug In America (2013) concluded that Roadster batteries should retain between 80 to 85 percent of their original capacity after 100,000 miles. According to a Dutch study (look: Nolan 2015), after 120,000 miles of driving Model S will retain approximately 90 percent of its range. Considering that 93 percent of

people drive less than 100 miles a day, Model S' range could be acceptable to many even with a 50 percent battery capacity. Therefore it will depend on the driver what is an acceptable range before replacing the battery pack. Nevertheless when a battery pack needs to be replaced a new battery pack for Model S' 85 kWh model costs 12,000 dollars. On the other hand also gasoline cars need to be serviced and after long periods of use their engines need to be replaced also.

According to Sustainability Group's study (Slavin 2014), main barriers to EV purchase were first the vehicle cost, second its range and third access to charging. Today EV's charging takes a long time and charging availability is limited. The limited availability means that often people do not have the possibility to charge their cars at home and there are not as much charging stations as there are fueling stations.

One additional small disadvantage of EVs is the fact that batteries discharge their power through time, if not plugged in. But, according to Tesla (Tesla Motors Blog: plug-it, 2012) the process is slow: "A plugged-in Tesla is not only charging its battery, it is also keeping key systems within the car functioning properly. Model S battery parked with 50 percent charge would approach full discharge only after about 12 months. Model S batteries also have the ability to protect themselves as they approach very low charge levels by going into a "deep sleep" mode that lowers the loss even further. A Model S will not allow its battery to fall below about 5 percent charge. At that point the car can still sit for many months. Of course you can drive a Model S to 0 percent charge, but even in that circumstance, if you plug it in within 30 days, the battery will recover normally." (Tesla Motors Blog: plug-it, 2012.)

4.1.2 Consumers' views on cars and electric vehicles

As we earlier discovered, if new technology is functional, gives pleasure and reflects one's self, it is often adopted. In general car use and ownership is also linked to the same instrumental, hedonic and symbolic attributes. It is also suggested that these same attributes influence the adoption of EVs. (Heffner, Kurani & Turrentine, 2007.) RAND (2012) found that the biggest barriers for EV adoption are limited range, long recharge time and high purchase price. Schuitema et al. (2013) see that instrumental

attributes, such as driving range are found to be important because of their influence on perceptions of hedonic or symbolic attributes of EVs or both. In other words if people perceive EVs' functionality to be bad, they link it to less joy and pleasure and a negative social identity in owning and driving an EV.

However Schuitema et al. (2013) add that the evaluation of EVs' attributes is subjective. Those who identify themselves as pro-environmental had more positive evaluations of EVs' attributes. On the other hand people who saw themselves as car-authorities had a weak correlation to the perceived attributes of EVs: "It is an important research finding since it suggests that those people who are key influencers of others' opinions in relation to cars have yet to be convinced about the merits of EVs." I would like to question this finding because RAND (2012) found that consumers' initial unfamiliarity to EVs might be a barrier to wider use. Therefore people who identify themselves as car-authorities might not understand all of the benefits the 2012 Model S has achieved and all of the complexities of a systemic innovation. Both are described in detail in the systemic innovation chapter.

A survey by Sustainability Group (Slavin 2014) studied people's main drivers and barriers of EV adoption. The main drivers to adopt EVs divided by: fuel economy for 69.8 percent, feeling good for 12.8 percent, environment for 10.5 percent and technology for 1.1 percent. The main barriers to adopt EVs divided by: the vehicle cost for 46.3 percent, range for 27.4 percent, no access to charging for 21.3 percent and charge time for five percent. Therefore if the main barrier of price of EVs lowers in the future, the main driver of fuel economy becomes more relevant. A study by Lim, Mak and Rong (2014) found that alongside of range anxiety, people also have resale value anxiety towards EVs.

Since most see vehicle cost and limited range as the biggest problems, Deloitte (2011) studied in its survey what are people's expectations on EVs' purchase cost and range. The results showed that 80 percent of respondents expect EVs to have a range of at least 100 miles, 60 percent expect it to be over 200 miles and 37 percent expect it to be 300 miles or more. Interestingly 93 percent of people drive less than 100 miles a day (National Household Travel Survey 2009). In regard to purchase cost Deloitte (2011) found that 47 percent of respondents expect EVs' price to be 20,000 to 30,000

dollars, 31 percent expect it to be less than 20,000 dollars and 14 percent expect it to be 30,000 to 40,000 dollars. According to RAND (2012), when people were asked to put the size of a car, its top speed, fuel economy and acceleration into order of importance when buying a new car, people were willing to pay more money for higher top speed and for faster acceleration.

4.1.3 Tesla Motors electric vehicle models and their sales

Figure 5 shows Tesla's yearly sales numbers from 2012 to 2020 and the prices of its EVs. The figure is adapted from Loveday's (2014) article. The sales numbers from 2012 to 2013 are actualized figures, while 2014 was Tesla's expectation for the year. According to Musk (Automotive News World Congress 2015) the 2014 expectation has been exceeded. Tesla has stated that it will aim to sell 500,000 EVs per year by 2020. This will be driven with the 2017 release of Model 3 (III) that is aimed at the mass market. The other yearly figures are expectations between 2014 and 2020 from Loveday's (2014) article. In this chapter I will also present Tesla's current vehicle models and its future models.

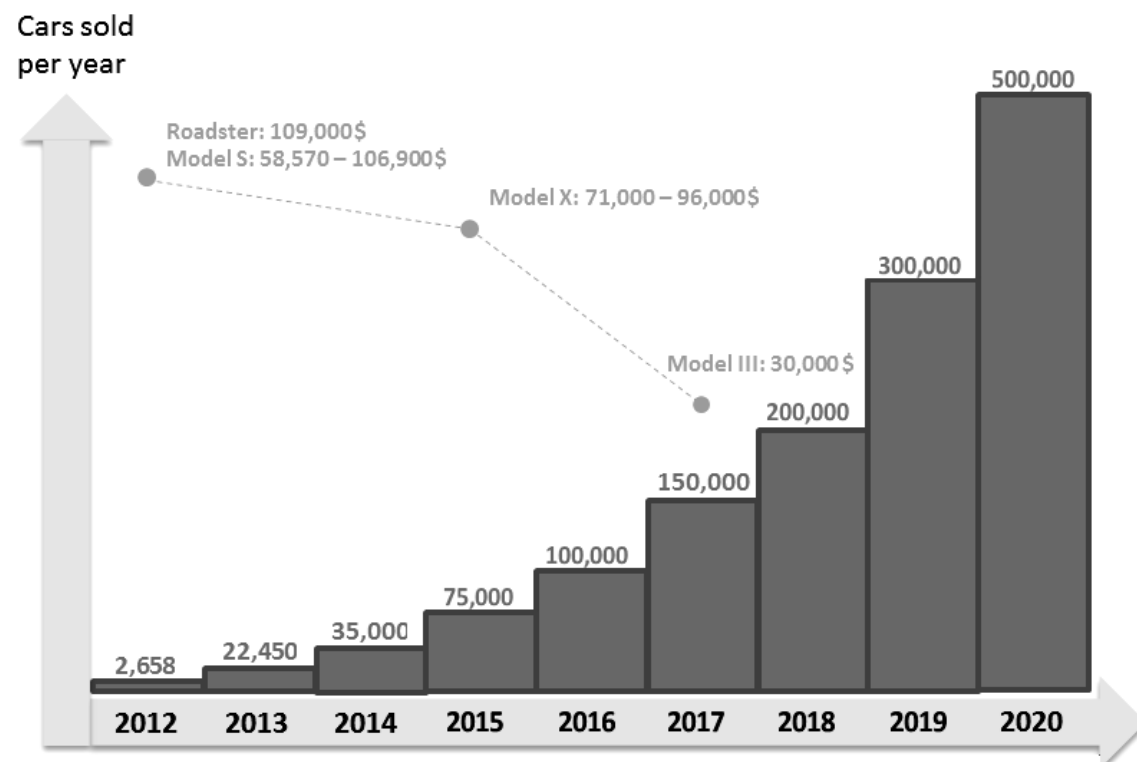


Figure 6 Tesla Motors yearly sales per unit and vehicle prices (adapted from: Loveday 2014)

Figure 5 illustrates what Schmidt and Druehl (2008) call a method of high-end encroachment. It explains how a company enters into a market. High-end encroachment means that the new product takes sales away first from the high-end of the market and thereafter moves towards the low-end of the market, and vice versa. Tesla has used high-end encroachment as their method to enter the car industry: while the price of each model of EV goes down, the sales numbers go up. Model 3 aims to cut the price of EV in almost half in five years.

Tesla is not the first EV manufacturer to enter the market from the high-end side. Schiffer (2000) notes that at the end of the golden age of EVs in 1912, Model T's sold for 525 dollars, while EVs sold from 850 to 5000 dollars. Nevertheless there were 30 EV manufacturers. NBC Bay Area (2009) news article adds that Tesla's strategy to first entice affluent buyers is a strategy well known in Silicon Valley and in the global technology industry. Often first versions of mobile phones and laptops start at a high price but drops as the technology matures and production volumes increase.

Musk (Automotive News World Congress 2015) sees that Tesla has already secured some degree of success and next Tesla's focus would be on the magnitude of it. He estimates that Tesla may be able to get to a "few million cars" by 2025. To get there Musk sees that Tesla needs to be focused on production growth, not demand growth. He said that ultimately Tesla's mission is to drive the world to electric cars. Therefore Tesla aims that EVs succeed as a disruptive innovation.

Tesla Motors Electric vehicle sales

Today Tesla has come quite far from its release of the first generation EV platform of Roadster in 2008. Nevertheless Roadster was the first EV to break all the records with its 53 kWh battery: it was the fastest, it had the longest range of 244 miles, first production car to use lithium-ion batteries and in general a two-seated sports car that could challenge its gasoline car competition. The price of Roadster was 109,000 dollars and its production ended in 2012. Tesla sold approximately 2,600 Roadsters.

Model S came out in 2012 with initially 60 kWh and 85 kWh battery options, but in 2015 the 60 kWh was updated to 70 kWh with Tesla's new all-wheel drive system to increase the range even more. Base prices for Model S range from 75,000 to 93,400

dollars with ranges from 240 to 270 miles. Even though Roadster had broken all of the previous EV performance records, not only did Model S match its performance, but it revealed the true competitiveness of an EV against gasoline cars. As Model S has received multiple car of the year awards, I see that media's focus has been rightly on the attributes of Model S as a usable car, rather than focusing on its high price or charging challenges. The advances Model S has made on battery technology and on car design will be presented in the systemic innovation part of this research. According to Cobb (2015) Tesla has sold 56,782 Model S' from 2012 to end of 2014.

In October 2014 Musk unveiled a new version of the luxury electric car maker's Model S sedan that includes all-wheel drive and self-driving "auto pilot" features. The Model S is called P85D and its price is 105,670 dollars. According to Musk (Tesla Motors blog: Dual motor Model S and autopilot, 2014) P85D is the fastest accelerating four-door production car of all time. It has two motors, one for the front wheels and other for the back wheels. This combined with the low center of gravity of Model S' platform makes the car's road holding and handling the most capable of any vehicle ever produced. Even though the P85D has two motors, it still gains an additional 10 miles of range because of its precise balance of power between the two motors. (Tesla blog post: Dual motor Model S and autopilot, 2014.) With the addition of P85D to the Model S fleet, Tesla expects to see a 50 percent increase in net orders and deliveries of Model S in 2015 (Sparks 2015).

In February 2012 Tesla revealed its next model, Model X in an event hosted by Musk (Tesla Model X reveal 2012). Tesla will start delivering them in 2015. It is a crossover utility vehicle based on the same second generation platform that Model S is built on. According to Musk, it will be 10 percent heavier than Model S and share 60 percent of its parts with it. It will have 10 percent less range, but the batteries will have the same options as Model S, 70 kWh and 85 kWh with respective base prices from approximately 71,000 to 96,000 dollars. According to Musk "It has more utility than a minivan, and better performance, much better performance, than an SUV". Musk also said that the car will have room for seven adults and their luggage and that its four-wheel drive system will be more advanced than in any other car seen before. Additionally the Model X has large gulf wing doors that open up vertically to ensure

easy opening at tight parking spaces. (Tesla Model X Reveal 2012.) This feature can be seen in Picture 3, taken from the reveal event. Musk said in Automotive News World Congress (2015) that Tesla already has all orders for Model X for year 2015. Current orders will be delivered 2016. Tesla stated in February 2015 that it had received 20,000 reservations of Model X's (Sorokanich 2015).



Picture 3 The Reveal Event of Model X in 2012. Elon Musk entering inside the vehicle through its gulf-wing doors.

Model 3 (Model III) will be the first model to be strongly focused towards the mass market. It will be Tesla's third generation platform. According to Tesla's design chief officer Franz von Holzhausen, it will "be an Audi A4, BMW 3-series, Mercedes-Benz C-Class type of vehicle that will offer everything: range, affordability, and performance with a starting price of 30,000 dollars". (Chow 2015). It will be 20 percent smaller than Model S and have a range of 200 miles. Musk said in Automotive News World Congress (2015) that the challenge of designing the Model 3 will be not making a smaller Model S. He wants the car to be drastically different to other cars on the road while still being really useful. According to a Tesla slide presentation in June 2012 (look: Vijayenthiran 2013), the Model 3's third generation platform might be used to produce another crossover utility vehicle such as Model X, but smaller and of course cheaper.

The results showed that 80 percent of respondents expect EVs to have a range of at least 100 miles, 60 percent expect it to be over 200 miles and 37 percent expect it to be 300 miles or more. Interestingly 93 percent of people drive less than 100 miles a day (National Household Travel Survey 2009). In regard to purchase cost Deloitte (2011) found that 47 percent of respondents expect EVs' price to be 20,000 to 30,000 dollars, 31 percent expect it to be less than 20,000 dollars and 14 percent expect it to be 30,000 to 40,000 dollars.

Now I will estimate the potential mass market capability of Model S in relation to price and range and people's relation to cars. According to International Organization of Motor Vehicle Manufacturers, United States produced over 4.3 million cars in 2013. Since approximately 60 percent of all of the housing units in United States are detached homes, this reflect how many have the capability to charge an EV at home. As we earlier discovered 60 percent of people expect EVs to have a range of over 200 miles and 14 percent expect EVs to be priced at 30,000 to 40,000 dollars. Therefore people have the most challenging expectations of EVs in relation to Model 3's price of 30,000 dollars. With the price expectation in mind, if Tesla's Model 3 is capable of competing with gasoline cars on instrumental attributes, theoretically Model 3's market share could be 602,000 cars sold yearly. Considering that in United States the average price of a car in 2013 was 31,252 dollars (Healey 2013), I see people's expectations on EVs' price to be quite strict. As I will later describe, Tesla already has recharging technology that can compete with fueling in speed, and in practice most people don't need more than 200 miles of range on a car, the potential market should be much higher. Also considering that the average price of a car has increased almost 5,000 dollars in 10 years (Healey 2013), the potential market in 2017 should be even higher than that. In the next chapter I will calculate the costs of using a Model S compared to a gasoline car which will show how well EVs save on costs in the long term.

I see that one of the challenges Tesla faces is keeping all of its current EV owners happy. As Tesla's focus is so systemic, it has to focus on multiple areas at the same time. Considering that Roadster came out in 2008 and all of the next EV models until 2017 will be cheaper and segmented more towards the mass market, there has been no

mention of a next generation Roadster. Also the resale value of the earlier models, that is an anxiety for consumers, could be affected since Model 3 aims to cut the price down in half while retaining most of the range.

Nevertheless in 2014 Musk announced (Tesla blog post: Roadster 3.0, 2014) that Roadster owners would get an upgrade called “Roadster 3.0” if they so wished. The upgrade will be installed into the frame of the old Roadster, but the price of the upgrade has not been released. Even though it will not be a new Roadster, Gordon-Bloomfield (2015) noticed that “It will continue to promote Tesla as the only automaker whose cars get better (and more advanced) with age.” Musk supported this notion in a recent interview (RTL Z 2014) by saying that when Tesla comes up with improvements to its cars, they are instantly rolled into production, compared to other big manufacturers with annual model year steps. Therefore Tesla’s cars are under constant revolution.

4.1.4 Cost calculations between electric vehicles and gasoline cars

In this chapter I will show the price gap between gasoline and electricity in different countries after using an EV and a gasoline car for 10,000 miles. To understand costs on a larger scale, I will present two additional cost calculation comparisons between EVs and gasoline cars. The first calculation will include also both cars’ servicing costs, as in the price of buying a new battery pack for Model S and a conservative estimate on the servicing costs of a gasoline car. To understand the costs of owning an EV, the second calculation will include also the purchase price of Model S and the purchase price of similarly segmented and performing diesel car.

The main reason for using two different cost calculations relate to people’s drivers and barriers of EV purchase. As we earlier discovered, most people feel that their main driver for buying an EV is fuel economy, but their main barrier is vehicle cost. Because Tesla will produce a mass market EV in 2017, it is important to do a calculation that does not include the purchase price of an EV. On the other hand it is important to understand how competitive Model S is today and include its purchase

cost in the second calculation.

The price gap between gasoline and electricity

Figure 6 represents the price gap between electricity and gasoline in different countries. The calculation is based on Loveday's (2014) article that was done by using a Nissan Leaf (EV) and a Toyota Camry for 10,000 miles and comparing their fueling and recharging costs. Since Model S has the same energy consumption as a Nissan Leaf, the figure is adapted for the use of Model S. Model S has an energy consumption of 29 kilowatt hours per 100 miles and Toyota Camry has a fuel consumption of 28 miles per gallon. The figure shows that in Norway a Model S saves 3,065 dollars in fuel costs, while in Saudi-Arabia it saves only 100 dollars.

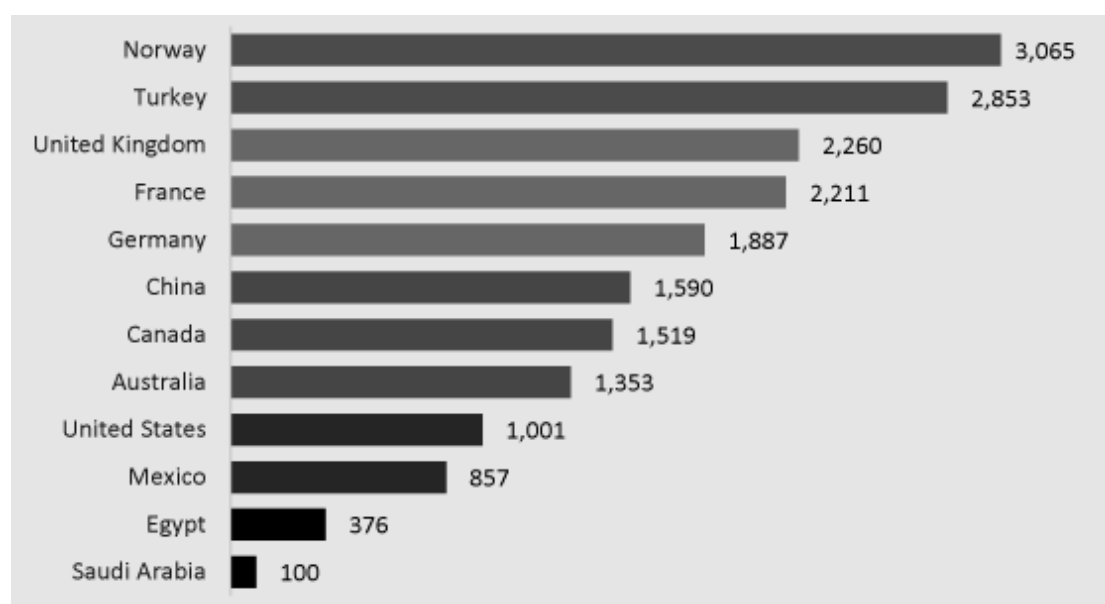


Figure 7 Price gap between gasoline and electricity in different countries. Based on Model S and Toyota Camry after 10,000 miles of driving. (Adapted from: Loveday 2014.)

Cost calculation on using an electric vehicle

Since EV batteries lose gradually their maximum power capacity, they need to be changed after long periods of use. With Model S the price of a new battery is 12,000 dollars. Table 1 includes the cost of a battery replacement in a cost calculation. In it I have included Model S, Toyota Prius and Toyota Camry after 120,000 miles of driving. Toyota Camry has 28 miles per gallon consumption and Toyota Prius 48

miles per gallon consumption. In relation to Model S' performance, such as acceleration, the two Toyotas do not represent comparable fuel economies, but as Toyota has sold yearly over 200,000 of its environmentally friendly Prius' in United States, it will be a good example of a successful and an extremely economic vehicle.

According to a study by American Automobile Association (2013) the maintenance costs for a large sedan after 120,000 miles comes up to 6480 dollars. I will use this estimate for Toyota Camry and Prius. According to the study the maintenance cost is calculated based on normal and routine maintenance on a car. The change of a battery pack on an EV cannot be seen as a routine maintenance since it is such a large part of the functionality of an EV. For EVs to have a two times higher costs of servicing compared to a gasoline car is an extremely conservative estimate. Especially when Tesla's electric engine has only one moving part, while a gasoline engine has hundreds (Tesla Motors Facebook post 2013). Additionally the price of Prius' battery change is not included in the calculation.

All of the calculations are based on an application located at Tesla's website (Tesla website: Go electric). This enables customers to see the costs of a gasoline car and EV at different miles driven and at different price points of gasoline and electricity. For all of the calculations the price of gasoline and diesel is from Global Petrol Prices website (retrieved 27.04.2015) and the electricity costs for United States is from Tesla's estimation and for Norway from Statistisk Sentralbyrå (2014).

The cost calculation is done on United States and Norway because they both have the two largest sales of Model S' in the world. Furthermore Norway has a large price gap between gasoline and electricity prices while United States has one of the smallest. I have set the maintenance cost for gasoline car the same for Norway and United States because Norway has a generally high cost of living

Table 1 Costs of usage comparison after 120,000 miles in United States and Norway

UNITED STATES			
	Recharging/fueling costs (\$)	New battery pack cost / maintenance (\$)	Total costs (\$)
Model S	4,190	12,000	16,190
Toyota Camry	16,714	6,480	23,194
Toyota Prius	9,957	6,480	16,437
Model S savings in United States: 247 dollars against Prius and 7,004 dollars against Camry			

NORWAY			
	Recharging/fueling costs (\$)	New battery pack cost / maintenance (\$)	Total costs (\$)
Model S	3,841	12,000	15,841
Toyota Camry	32,443	6,480	38,923
Toyota Prius	19,328	6,480	25,808
Model S savings in Norway: 9,967 dollars against Prius and 23,082 dollars against Camry			

The results show that in United States a Model S saves 247 dollars against a Prius and 7,004 dollars against a Camry. In Norway the respective savings are 9,967 dollars and 23,082 dollars. Considering that the maintenance cost is a conservative estimate, Model S most likely saves even more in use in both countries. Interestingly even though United States has one of the lowest gasoline prices it is still cheaper to use an

EV. The cost savings from use become more relevant as the price of Tesla's EVs goes down. With Model 3 the price of a battery pack should be much lower since it is a smaller car and its production depends on cutting down the cost of batteries.

The calculation is done on 120,000 miles of driving. According to a Dutch study (look: Nolan 2015), after 120,000 miles a Model S would have 238 miles left in its range. Considering that 93 percent of people drive less than 100 miles a day, Model S' range would be sufficient for most even after 120,000 miles. Nevertheless people might be motivated to change the battery even sooner because as the maximum range drops, the important performance metrics such as acceleration and top speed drop also.

The calculation does not include all of the savings EV could achieve from usage. These include some of the usage incentives governments place on EVs. According to Ballaban (2014) in Norway an EV owner receives benefits, such as the annual registration fee and tolls are waived and they are granted an access to less congested traffic lanes.

Cost calculation on owning an electric vehicle

Next I will calculate the total costs of owning an EV. To see how competitive Model S is in total costs compared to a gasoline car, also the purchase cost of the car needs to be taken into account. For the comparison to be accurate, it is important to compare Model S to a similarly segmented and performing regular car. I chose BMW 535 diesel for the comparison. It is also a high-end large sedan with a similar acceleration and a fuel economy of 30 miles per gallon. Table 2 represents the total cost comparison between the cars in United States and Norway. Costs such as insurance were not included since their variation between EVs and gasoline cars do not have a significant affect. The usage costs for Model S and the servicing costs for BMW are from the previous calculation.

Table 2 Costs of owning a vehicle after 120,000 miles in United States and Norway

UNITED STATES			
	Purchase price (\$)	Usage costs (\$)	Total costs (\$)
Model S	79,900	16,190	96,090
BMW 535d	57,100	17,680	74,780
Model S total savings in United States: negative 21,310 dollars			

NORWAY			
	Purchase price (\$)	Usage costs (\$)	Total costs (\$)
Model S	92,000	15,841	107,841
BMW 535d	110,000	25,280	135,280
Model S total savings in Norway: 27,439 dollars			

In United States after 120,000 miles Model S is 21,130 dollars more expensive to own compared to the BMW 535d. In Norway Model S is 27,439 dollars cheaper to own. The large price gap can be explained by Norway's incentives towards EV owners. Ballaban (2014) found that a person buying an EV in Norway receives savings from sales taxes and the annual registration fee is waived. This has resulted in high Model S sales in Norway. Tesla sold 1,500 Model S' in Norway in March of 2014. It was the highest selling car of the month and the highest selling car of all time in a period of one month in Norway. (Ballaban 2014.)

Boston Consultin Group (2009) found that China and Europe are seen as the biggest markets for electric cars in 2020 and not United States, as many might think.

According to the gasoline and electricity price gaps, European countries are by large at the top of the list. Based on all of the previous data presented, I believe Norway and United States, as with the electricity and gasoline price gaps, are at the opposite ends of total cost savings in EV usage. As Norway and many European countries have a higher general cost of living than United States, I see many European countries and even China achieving lower costs than United States in owning and using an EV.

The results for United States and Norway reflect the consumer behavior of EV adopters. Even though EVs are more expensive to own in United States, from all of the 56,782 Model S' sold in the world before 2015, 65.3 percent were sold in United States. This entails that people are willing to buy EVs even if they are relatively more expensive. This finding correlates with the history of EVs and their golden age. On the other hand Norway proves that EVs can be cheaper to own and people certainly appreciate this as an attribute of an EV.

4.2 Capabilities of Tesla Motors: Elon Musk

To understand Tesla we have to begin with the main figure of the company, its CEO and co-founder Elon Musk. Again if we refer to the theory of five critical innovation factors, executive direction is at the top of the pyramid. Musk is therefore in charge of the company's project teams, innovation strategies and internal structures. McCarthy (2013) found that Musk has often been compared to Henry Ford and Steve Jobs.

What makes Musk's role in Tesla's success and its future extremely interesting, is his other three companies' connections with Tesla. In an interview for National Geographic (2013) Musk was asked what had motivated him to this point with his companies, and he answered: "in college I tried to think about what are the areas that would most affect the future of humanity. So the three things were the internet, making life multi-planetary and sustainable energy. So that's what really ties my

companies, is that thought from 20 years ago.”

First Musk entered the internet business. In 1999 he co-founded PayPal and sold it in 2002 to eBay for 1.5 billion dollars. Being the largest shareholder of PayPal, Musk received 165 million dollars. (Welch 2014.) Now he had the founding wealth to see his other two visions through. Welch (2014) describes that after Musk saw that NASA had some cutbacks in its space programs he decided to create his own space exploration company Space Exploration Technologies (SpaceX). Musk used 100 million dollars of his early fortune and found the company in 2002. SpaceX has been since working in close contact with NASA. After NASA’s Space Shuttle was retired in 2011, SpaceX uses its shuttles to make deliveries to the International Space Station. According to CNN (2014) the end goal for SpaceX is to make life multi-planetary. Musk is aiming to cut down the cost of human spaceflight by a factor of 10 which would enable taking humans to mars by the middle of 2020.

In a Stanford University Business School interview (2014), Musk explained that he envisioned in his college years in 1991 that all vehicles would become electric. Therefore in 2003 he entered the EV market by creating Tesla Motors and coincidentally fulfilled his three part vision. Musk’s thoughts on entering the car industry: "New technology in any field takes a few versions to optimize before reaching the mass market, and in this case it is competing with 150 years and trillions of dollars spent on gasoline cars.” (Tesla blog: lotus position 2006).

In 2006 Musk decided to create another sustainable energy company SolarCity. It is the second largest solar panel installation company in United States. Today Musk is the CEO and CTO of SpaceX, CEO and chief product architect of Tesla and chairman of SolarCity. What makes his companies interesting is that they are not isolated from each other, but they reflect a larger system created by Musk. Figure 7 represents Musk’s organizations’ current and possible future interconnections between each other.

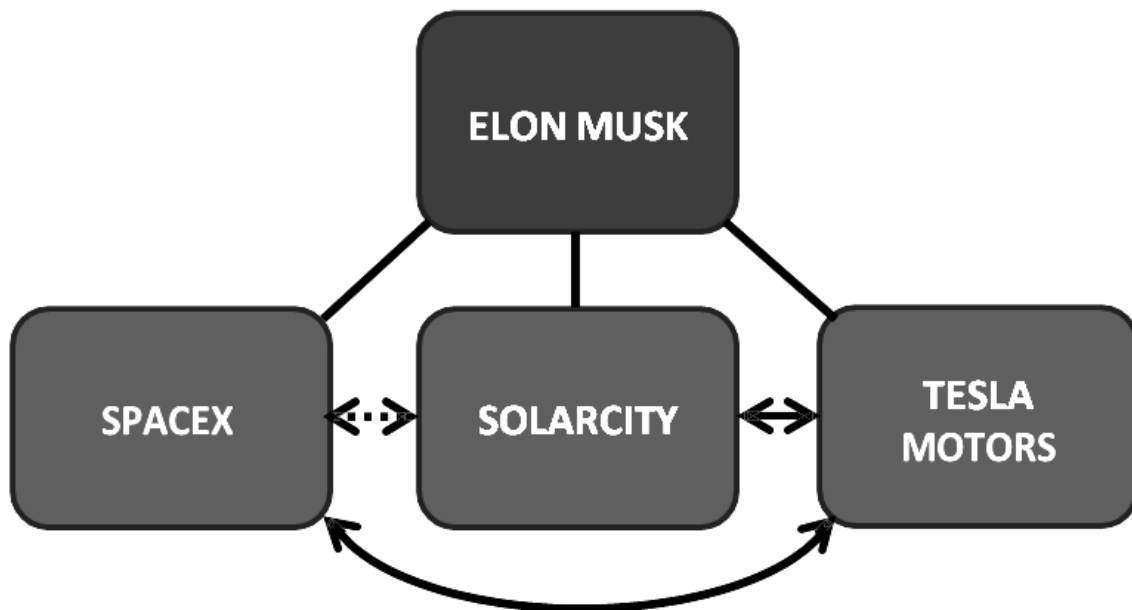


Figure 8 The organizational system of Elon Musk: interconnections between the companies.

Not only is Musk involved in the systemic innovating of EVs, he is also expressing a larger system created by the interconnections between his three companies. The dotted arrows in Figure 7 indicate a possible transfer of resources between the companies in the future, while the solid arrows indicate existing transfer of resources. Tesla aims to create a 100 percent renewable energy source for their public Supercharger stations. SolarCity will be the provider of solar panels to the stations. Tesla is additionally aiming to make the solar panels independent from power grid. This would be accomplished by coupling the solar panels with batteries and since Tesla will be a large producer of batteries with its Gigafactory, this is easy for them to achieve. (Massachusetts Institute of Technology 2014.) The interconnections expresses how Musk is also using SolarCity as one actor of systemic innovating of EVs. This is beneficial both for the individual companies and to the business system of EVs.

The sharing of resources from Tesla and SolarCity to SpaceX became an indirect talking point at the Massachusetts Institute of Technology (2014) interview. Musk was asked about how the energy needs would be met if the colonization of Mars were to happen. He replied by saying that solar panels would be a possibility. Again, if this

would happen, SolarCity could provide the panels, while Tesla could provide the battery packs for the panels. The connection with SpaceX and Tesla exists with their similar production materials and techniques: “yeah we have lot of advanced light-weight aluminiums and advanced joining techniques, new types of welding that we use in Model S too”, Musk stated in an Automotive World Congress (2015) interview.

Musk co-created Tesla with JB Straubel, Martin Eberhard and Marc Tarpenning, but Musk can be seen to have the largest role in the company. In the early investing rounds of Tesla, he invested 74 million dollars of his own money to the company (Reed 2009). Also according to Tesla’s website Musk oversaw the designing of Roadster at a detailed level. In 2008 he took the responsibilities of CEO and thereafter continued on ramping up the sales of Roadster and next focused on designing the Model S. (Tesla website: executives.)

According to Summers (2014), Musk’s net worth was estimated at 12 billion dollars in February of 2014 and according to Nelson (2014) he is willing to use his own money on Tesla if needed. When Tesla created a buyback guarantee program that promises Tesla to buy back used Model S’s from its customers at a competitive price, Musk wanted to reassure the hesitant customers: “Even if Tesla is unable to honor (the buyback guarantee), I will personally do so. That's what I mean by putting my money where my mouth is.”

Musk has said that his goal is not to make profit, but to make his vision a reality. He clarified that growing Tesla’s profit margins at this point could be possible but not a smart move. (Massachusetts Institute of Technology 2014.) I believe Musk referred to the systemic innovating needs of EVs. There are such massive investing, inventing and growing requirements in the business system of EVs that it would be irrational to focus only on short-term goals.

Fitzgerald (2014) described in his news article the capabilities of Musk in relation to Tesla’s fast growth: “Creativity as a thinker who can’t be boxed in by entrenched

competitors, the ability to cheerfully put tens of millions of his own money behind his vision when necessary, a solid grasp of what technology means for the industry he operates in... all of these are great qualities in a CEO. Any company, big or small, is lucky to have a chief executive with just two of them. Tesla has all three in Elon Musk.” In relation to the pyramid model’s five critical innovation factors, I would go as far as to say that the executive direction from Musk can be described as a “heroic” effort as the main contributor in Tesla’s current success. Musk said in Automotive World Congress (2015) interview that he will be the CEO of Tesla to see Model 3’s designing and production through, but would re-evaluate his position thereafter. Nevertheless he stated that he wants to stay in Tesla as long as he lives.

4.3 Systemic innovating by Tesla Motors

In this chapter I will assess how Tesla has implemented systemic innovating. In relation to the theory framework of this research, Tesla as a leading company sends strong signals, especially with the creation of innovations and architectures to the EVs’ business system. Figure 8 represents the systemic innovating timeline of Tesla. It starts from the introduction of Roadster in 2008 and ends up at 2017, when Tesla’s battery Gigafactory is planned to be operational and Model 3 enters the market. I will describe all of the steps in detail starting from the disruptive technology level of batteries, next on the level of a finished car and last on the external level of services such as Supercharger Stations. Much of Tesla’s actions show that it is duplicating gasoline cars’ business system on a large scale, but at the same time it is trying to isolate EVs from it.

2008: Roadster: proof of EVs disruptive capabilities

2008: Direct internet sales of EVs, no advertising and Tesla Stores that act in a similar way to Apple Stores (isolation from gasoline cars)

2012: First Supercharger Station. In 2015 more than 400 stations. Creating the future architecture of charging stations

2012: Model S: creating Model S platform architecture and increasing the disruptive capabilities of EVs

2013: Battery swap technology making swapping faster than fueling

2013: Creating a retail network for Tesla's used EVs (isolation from gasoline cars)

2014: Making Tesla's patents open to public. Systemic innovating requires open innovation (Maula et al. 2006).

2017: Battery Gigafactory. Increasing world's lithium-ion battery production two-fold. It should be a strong signal to all actors such as developer communities and related industries that are producing mobile phones and laptops. The larger context of a system created with Musk's three companies drives the economies of scale on battery production which results in cheaper EVs.

2017: Mass market Model 3. Made possible with Gigafactory.

Figure 9 Systemic innovating timeline of Tesla Motors

I believe Tesla's decision to release its patents to the public signifies Tesla's systemic innovating as a whole. As Maula et al. (2006) found, systemic innovation requires open innovation that means an open exchange of ideas and resources which will benefit all of the actors within the business system. Musk wrote in June 2014 (Tesla blog post: all our patent belongs to you, 2014.) Tesla's reasoning for this action: "They have been removed, in the spirit of the open source movement, for the

advancement of electric vehicle technology. Tesla Motors was created to accelerate the advent of sustainable transport. If we clear a path to the creation of compelling electric vehicles, but then lay intellectual property landmines behind us to inhibit others, we are acting in a manner contrary to that goal. Tesla will not initiate patent lawsuits against anyone who, in good faith, wants to use our technology.”

Musk adds: “At Tesla, however, we felt compelled to create patents out of concern that the big car companies would copy our technology and then use their massive manufacturing, sales and marketing power to overwhelm Tesla. We couldn’t have been more wrong. The unfortunate reality is the opposite: electric car programs (or programs for any vehicle that doesn’t burn hydrocarbons) at the major manufacturers are small to non-existent, constituting an average of far less than 1% of their total vehicle sales. We believe that applying the open source philosophy to our patents will strengthen rather than diminish Tesla’s position” (Tesla blog post: all our patent belongs to you, 2014.)

4.3.1 Disruptive technology level: batteries

Gigafactory

Panasonic produces batteries for Tesla. Musk said in Tesla’s shareholder meeting (2014) that Panasonic provides the necessary cells and equipment to be able to build the battery packs. Since batteries make up a large portion in the price of Model S, Tesla needs to produce them on a large scale to generate economies of scale. Tesla wants to solve this challenge by creating a Gigafactory to produce batteries. The Gigafactory will be functional in 2017 and aims to produce more batteries in 2020 than all of world’s battery producers did in 2013. This should translate into a capability to produce 500,000 vehicles a year by 2020. The Gigafactory will lower the price of batteries at least 30 percent. This will be necessary to be able to produce Model 3 with a price of 30,000 dollars and a range of 200 miles. (Tesla shareholder meeting 2014.)

Musk said in Automotive World Congress (2015) that the factory costs approximately

5 billion. Tesla's share of the costs will be over two billion dollars, Panasonic will pay little under two billion dollars and other industrial partners producing such precursor elements such as anode, cathode and separators, will contribute 500 to 600 million dollars. According to Musk the state of Nevada will support the effort by "few hundred millions" since it is being constructed there. Creating the factory will be a massive signal to the business system of EVs, such as other industries producing mobile phones and laptops and developer communities that are committed to the advancing of lithium-ion batteries. This should again affect their resource allocation towards batteries, which proves that external resource allocation is important also on the disruptive technology level, contrary to what Christensen (1997) and Maula et al. (2006) propose.

Figure 9 shows the customers of Tesla's Gigafactory and some of the earlier mentioned connections between Musk's three companies. Primarily the gigafactory produces batteries for Tesla's EVs, but it is also producing them for home owners and SolarCity. SolarCity would use Tesla's batteries for all of its solar panel customers: homeowners, Tesla's Superchargers and possibly SpaceX. If the Gigafactory is capable of reducing the price of batteries by 30 percent, it gives Tesla a competitive advantage in the production of EVs. In a way Tesla is creating the architecture with Gigafactory on how competitive EVs can be made. Especially incumbent companies should see this as a possible threat to their gasoline car production.

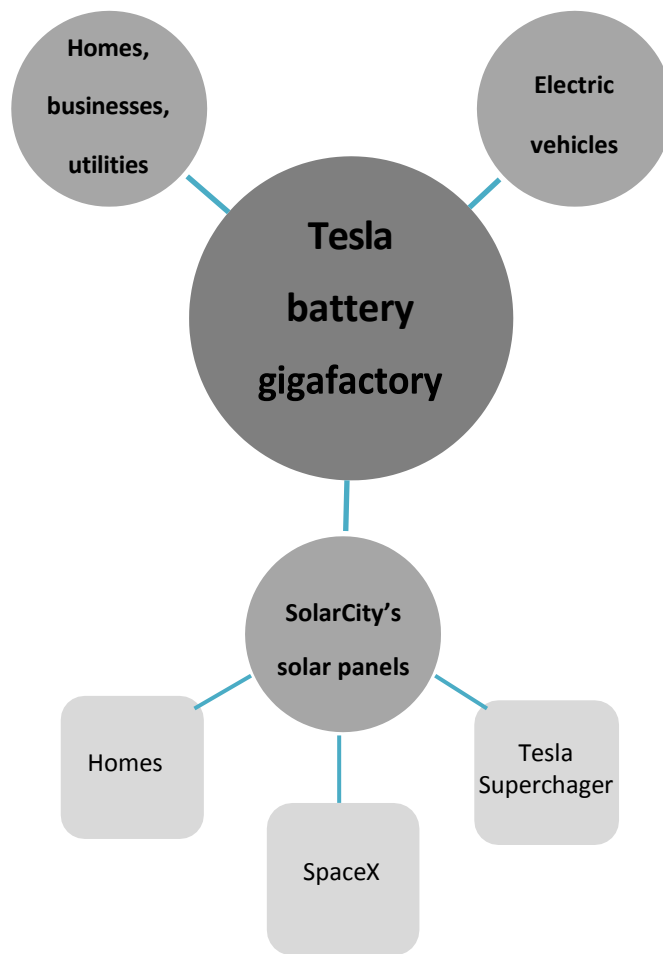


Figure 10 Customers of Tesla's battery gigafactory. Musk's other companies as future and potential customers of its batteries.

Tesla's batteries are not only going to homeowners with solar panels. In 2015 Musk revealed Tesla Energy (Tesla introduces Tesla Energy 2015). It aims to sell batteries to homes, businesses and utilities. Homeowners could buy what Tesla calls a Powerwall that stores energy into it either from solar panels or straight from the grid when utility rates are low. Musk said that ultimately the combination of solar panels and batteries would be the way to transform all of world's energy production into sustainable energy. (Tesla introduces Tesla Energy 2015.) Considering that all of Musk's three companies are committed to battery production, each of the companies aim to gain economies of scale in battery production. If Tesla's Gigafactory is capable of generating battery sales in all of the areas presented in Figure 8, the cost of batteries and the purchase price of EVs become lower.

Advancing batteries

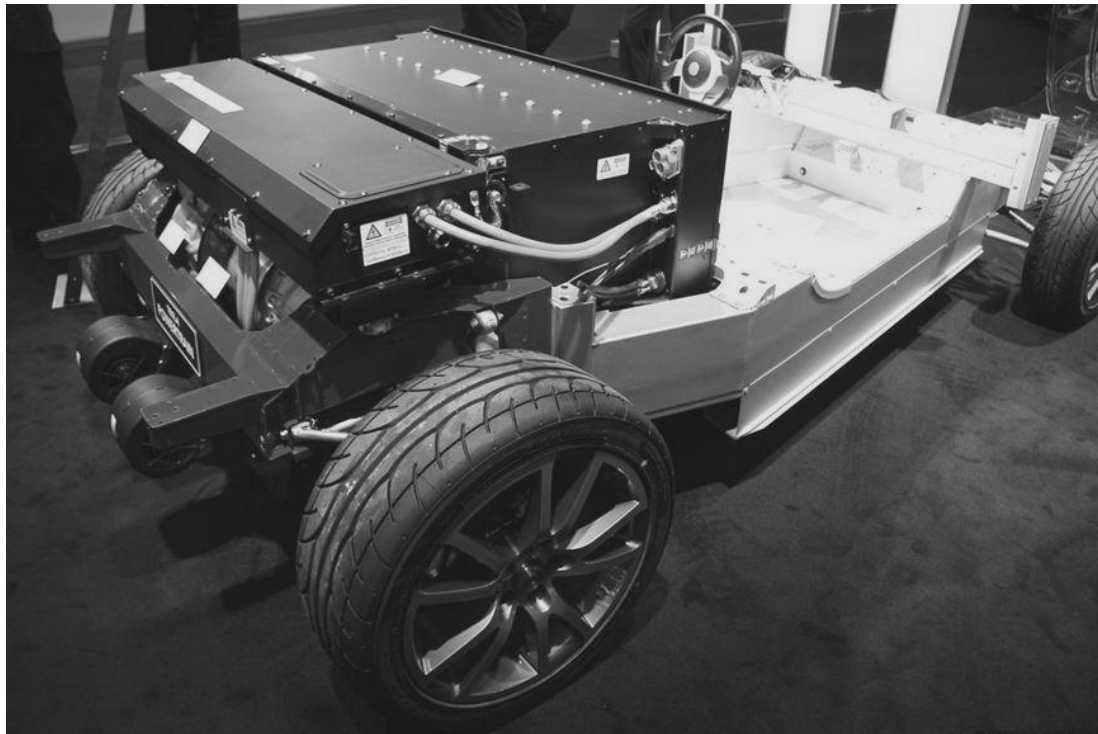
Tesla is not only focused on scaling up battery production, but their battery technology has also advanced since Roadster came out in 2008. When Tesla released the upgrade for Roadster (Tesla blog post: Roadster 3.0, 2014), they said that Tesla had identified a battery cell that has 31 percent more energy than the original Roadster cell. In practice this will mean that the old 53 kWh battery will be replaced with a 70 kWh battery while the size of the pack will remain the same. With a 31 percent increase in energy in seven years and a 30 percent reduction in costs by 2017, Tesla's systemic innovating efforts on batteries seem efficient.

4.3.2 Finished product level: electric vehicles

The most notable advancements Tesla has made on the finished product level include speed increases in vehicle production, second generation platform of Model S and the advancements made on the Roadster 3.0 upgrade. Musk said in Automotive World Congress (2015) interview that Tesla has doubled its weekly production in 2014. Faster production rates result in lower consumption of resources which in turn results in cheaper EVs.

The advantages of Model S' platform

Picture 4 shows the battery location for Roadster and Model S. In Roadster the battery is the large black pack at the back of the car, while in the Model S the battery is located within the platform of the car, spread throughout the bottom of the chassis. The placement of batteries within the bottom of the chassis of Model S has enabled advances on the finished product level relating to attributes such as performance, safety and spaces. These advances have not been previously seen in gasoline cars. *Importantly these advances can be seen as Tesla creating a successful platform architecture that could be used in the production of other manufacturer's EVs.*



Picture 4 Battery pack evolution from Roadster to Model S

The good driving capabilities of a car are partly the result of a low center of gravity, which is true for Model S' platform with its low placement of heavy batteries. According to Tesla, Model S' "rigid body structure, nearly 50/50 weight distribution and a remarkably low center of gravity, offers the responsiveness and agility expected from the world's best sports cars" (Tesla Motors website: Detroit2015).

The platform enables also a safer structure for the car. When Model S received five stars from Euro NCAP crash tests, Tesla wrote in a blog post (Tesla Motors blog: Model S Achieves Euro NCAP 5-Star Safety Rating, 2014) about the safety attributes regarding Model S: “Structurally, Model S has advantages not seen in conventional cars. It has a low center of gravity because its battery pack, the largest mass in the car, is positioned underneath the passenger compartment, making rollover extremely unlikely. It also has a large front crumple zone because of the lack of an engine, meaning it can absorb more energy from a frontal impact, the most common type of crash resulting in fatalities. Its body is reinforced with aluminum extrusions at strategic locations around the car, and the roof can withstand at least 4 g’s. It was for these reasons that Model S achieved 5 stars in every subcategory when tested by NHTSA in 2013.”

Since the platform is level and does not have a transmission or a gasoline tank, designing the rest of the car is more unrestricted. With Model S, the design resulted in a trunk that houses two extra seats and also what Tesla calls a “frunk”, a trunk-like cargo space in the front of the car, where gasoline cars have their engines. According to Consumer Reports, Model S offers the highest passenger capacity of any electric production passenger vehicle (Loveday 2013).

Roadster 3.0 upgrade

The Roadster 3.0 upgrade for 2015 shows that Tesla wants to keep all of its customers happy, but it also shows that Tesla is capable of making multiple advances to the frames of its old vehicles. According to Tesla (Tesla Motors blog: Roadster 3.0, 2014) Roadster 3.0 upgrade will change the old batteries to new ones, the shell of the car will be changed into a more aerodynamic mold and the tires will have a lower roll resistance. The battery will be changed from 53 kWh to 70 kWh. The new shell of the car will reduce drag by 15 percent which means that Roadster 3.0 will move on the roads with less resistance. The 20 percent improvement in roll resistance with better tires also results in less resistance. Tesla concludes that all of the upgrades will result in 40 to 50 percent improvement in range and see the Roadster 3.0 to be able to drive 400 miles on a single charge. (Tesla Motors blog: Roadster 3.0.) Tesla demonstrated

the Roadster 3.0's new capabilities by driving from Los Angeles to San Francisco. The trip was 340 miles and took under five hours. At the end of the trip the Roadster still had 20 miles in its range. (Tesla blog post: Roadster Road Trip Update: San Jose to Los Angeles on a Single Charge, 2015.)

Model 3

Model 3 will be a great challenge for Tesla. Essentially the doubling of world's lithium-ion production with Gigafactory will be the test to find out if Tesla is capable of driving down the cost of EVs. According to Musk (YouTube: Elon Musk Talks about Battery Size of Tesla Model 3, 2014) the car will be 20 percent smaller than Model S and have a 20 percent smaller battery pack and a range of 200 miles. He added that to achieve a total of 50 percent cost reduction in the purchase price, the battery pack's price has to be reduced by additional 30 percent in comparison to the car. This will be achieved by economies of scale, vertical integration and design innovation. (YouTube: Elon Musk Talks about Battery Size of Tesla Model 3, 2014.) The economies of scale refer to Gigafactory, vertical integration to the sharing of parts with Tesla's other EVs and design innovation to the 20 percent reducing in size and other design related reduces.

Nevertheless considering that Tesla has already improved the battery cell's capacity by 31 percent in seven years and it is planning to cut down the cost of batteries by 30 percent with Gigafactory, if Tesla is capable of advancing the cell at a same pace in the next two years, Model 3 will have a smaller battery with more power which affects the performance such as torque and acceleration. As we earlier demonstrated people are willing to pay more money for higher speed and acceleration. Tesla has already proven that it can cater to this need with the creation of Model S P85D, the fastest four-door production car ever built. With the additional knowledge Tesla has gained from creating Model S with its platform that beats gasoline cars on many levels, Model 3's advances in the finished product level of systemic innovation should be impressive.

4.3.3 External level services and strategies

The external level services of Tesla include Supercharger Stations and battery swapping, Tesla Stores, Service Centers, a retail network, direct sales and a decision to do no advertising. The interesting factor about these services is that with gasoline cars, most of these services, such as the selling, fueling, servicing and retailing of cars are often not run by car companies, but by independent companies as their own businesses. Tesla wants to keep the fate of its EVs in their hands at all times, from production to selling, recharging and servicing, all the way to reselling. These services and decisions will be covered next in depth.

Supercharger stations and battery swapping technology

Tesla unveiled in September 2012 its first six Supercharger stations in California. The stations enable Tesla drivers to get for free a half charge in as little as 20 minutes. In February 2015 Tesla made a blog post (Tesla Motors blog: 2000 superchargers) celebrating the milestone of 2,000 Superchargers worldwide in almost 400 Supercharger Stations in North America, Europe, Asia, and Australia. According to the blog “Tesla Superchargers enable free long distance electric driving across the United States, and up and down the West and East Coasts. They connect the United Kingdom to continental Europe and stretch from the south of France to northern Norway, far up into the Arctic Circle. In China, Superchargers link major cities along the coast, and we recently opened Supercharger stations in Japan and Australia. The Tesla Supercharger network is the world’s largest and fastest-growing fast-charging network. In 2014, the number of Superchargers increased five-fold. We plan to double the number in 2015.” (Tesla blog post: 2000 superchargers). Tesla’s Straubel says the company is working towards improving the recharging technology to be able to recharge a battery full in five minutes. He says that it will be really difficult but notes that the superchargers of today “seemed pretty crazy even 10 years ago”. (Bullis 2013.)

Tesla’s Supercharger Stations are not the first attempt to produce public charging stations for EVs. According to Kershner (2013) a company called Better Place had the idea of building up EV charging stations that would change the whole battery

pack to a fully charged one instead of regular charging. In 2008 they produced the first swapping station in Israel. Eventually the company spent 850 million dollars for the project since they thought there would be 100,000 EVs on the roads by 2010. Since it didn't happen, the company filed for bankruptcy in 2013. (Kershner 2013.) Better Place illustrates how an actor in the business system of EVs can create a bottle neck by focusing too much on external level services rather than core level technology and production of EVs. Tesla has proven how the business system of EVs can be gradually advanced in relation to the demand of EVs.

Even though Better Place failed, Tesla sees swapping stations as a good opportunity to advance its Supercharger Stations' capabilities. In January 2013 Tesla demonstrated its swapping technology in a Fast Pack Swap Event. The swapping is automated and happened in 90 seconds, which is twice as fast as filling up a large sedan with gasoline. In the event Musk emphasized that the swapping technology would mean that a Model S owner driving to a Supercharger Station could decide whether to recharge fast or for free. The swapping would cost around 60 to 80 dollars, which is close to gasoline prices. (Fast Pack Swap Event 2013.)

In December 2014 Tesla wrote (Tesla blog post: Battery Swap Pilot Program 2014) that they are implementing a pilot program for the technology by building one station capable of doing the swapping. Only invited Model S owners were chosen for the program and through it Tesla will assess if there is a demand for the swapping technology. In the pilot program the swapping happens in three minutes, but Tesla believes it is capable of doing it in the future in less than one minute. (Tesla blog post: Battery Swap Pilot Program 2014.)

Since slow charging can be seen as one of the biggest problems in the advancement of EVs, it is amazing to see Tesla creating a technology that is faster than the fueling of a gasoline car. On the other hand EV owners have the benefit of totally eliminating the time it takes to use public charging or refueling stations by charging their EVs at home or at work. I see that it is a smart decision from Tesla to try out the technology in a pilot program because the public charging capability might advance in a way that would make implementing the swapping technology expensive and unnecessary.

The benefits of swapping technology are evident, but it also has some challenges. According to Rogowsky (2013) the challenge with the technology is that Model S owners own also its battery packs. To solve this Tesla gives its customers the chance to pick up the original battery pack on a return trip. Another way would be that the customer keeps the battery pack he received and if it is newer, Tesla will bill the customer for the difference. The stations would cost 500,000 dollars to construct and have 50 new battery packs ready. (Rogowsky 2013.)

In my opinion one solution to the problem of battery ownership could be that the battery packs inside a Model S would be leased to its customers. This way the customer wouldn't own the batteries but would pay a monthly fee to Tesla to have them always in the car. This fee would pay for the service of swapping batteries and ensure customers that they would always have a functioning battery inside the car. Tesla would in theory be capable of selling its cars cheaper since the large portion of the price of a battery pack would not be included as such. Nevertheless, however the technology will be implemented it is still proof of Tesla being able to solve the challenge of slow recharging.

Tesla's EV rivals BMW and Nissan are keen on creating a global charging standard together with Tesla (Udland 2014). Musk said, as Tesla has opened its patents to the public, that "other manufacturers are free to use our charging technology" (Automotive News World Congress 2015). According to Tesla's website (Superchargers), their chargers are the fastest in the world. In California Tesla has nearly opened its first solar-powered Supercharger Station (Demorro 2015). With the addition of battery swap pilot program, it seems that Tesla is creating the architecture for future's charging stations.

Interestingly with gasoline cars, all the fueling stations are separately run businesses from the car manufacturers. What is more, the infrastructure to drill oil, produce gasoline and ship it is a complex and expensive transaction. Tesla is not only capable of running the charging stations by themselves, but it is also capable of generating the energy needed for its stations. Tesla has a far simpler and cheaper recharging

infrastructure compared to fueling stations and it is free for its customers. On the other hand it is providing free electricity for its users, therefore it is not a profitable part of systemic innovation in itself. It will be seen if Tesla will implement its battery swap technology on a larger scale and if this will make the stations profitable. Nevertheless the stations as part of systemic innovation should increase the competitiveness of Tesla's EVs and generate more income.

Tesla Stores and direct internet sales

Tesla has been selling Model S' directly from its website to its customers. Upon entering the Tesla's website's main page, you will encounter a large picture of a Model S and the buttons "order" and "test drive". By choosing to order, you will receive the Model S delivered to your home. By choosing test drive, you will be directed to your nearest Tesla Store. (Tesla website, 21.05.2014) Tesla Stores or galleries act as showrooms where customers can get to know Tesla and agree on test drives. The actual sales happen through their website. (McCarthy 2013.)

According to McCarthy (2013) this method of direct sales and manufacturer-owned stores largely emulate the way Apple has sold its electronics to the public. Tesla is the only automaker that sells directly to its customers, while other manufacturers are using independently owned dealerships. Tesla Stores are located in visible areas such as malls and shopping centers. (McCarthy 2013.) Picture 5 shows a Tesla Store in United Kingdom. The comparison to Apple Stores is evident: simple, clean and spacious areas to draw customers into. According to Reynolds (2013) "The showrooms (Tesla Stores) are only the size of a small shop, often only squeezing in a single vehicle into the space. Most cars dealerships would be lucky to get a hundred potential customers perusing the cars on their lot each day. But because of their location, Tesla gets tens of thousands of people walking right past their car, every single day."



Picture 5 Tesla Store in United Kingdom

Musk stated in a blog post (Tesla Motors blog: Tesla approach distributing and servicing cars) the company's reasoning for the direct-sales and Tesla Stores method: "By the time most people decide to head to their local dealer, they have already pretty much decided what car they want to buy, which is usually the same make as their old car. At that point it is largely just a matter of negotiating with the dealer on price. Tesla, as a new carmaker, would therefore rarely have the opportunity to educate potential customers about Model S if we were positioned in typical auto dealer locations."

Manufacturer-owned retail network

A study by Lim et al. (2014) found that alongside of range anxiety, people also have resale value anxiety towards EVs. The resale anxiety is easy to understand with Tesla's EV models. In 2008 Roadster cost 109,000 dollars and it has a range of 244 miles. Nine years later Tesla is aiming to produce Model 3 that will cost a third of Roadster while still having almost the same range. Understandably Model 3 should also affect the resale values of other EVs because of its cost effectiveness. Some customers might feel like they are not getting nearly as good of a performance in relation to the price with their old models.

Tesla has recognized the resale value anxieties of its customers. Nelson (2014) writes that Musk decided in April 2013 that the resale anxiety would be resolved by him personally guaranteeing the resale value of the Model S. In practice this meant that buyers who financed a Model S under certain terms have been given a contract allowing them to return the car after three years and recover 43 to 50 percent of its original value. The resale value was designed to duplicate the way a three year old German luxury car would hold its value. "Even if Tesla is unable to honor (the buyback guarantee) I will personally do so," Musk assured, with his net worth of 12 billion. (Nelson 2014.)

Nelson (2014) adds that the buyback guarantee might also be a huge possibility for Tesla. With it Tesla is also capturing the resale profit of its cars by controlling the retail market. John Krafcik, president of online car-buying service TrueCar Incorporated stated that Tesla might even earn more money on the second purchase of Model S than in the first one, making 6,000 to 10,000 dollars profit on each sale. These estimates seem likely considering that a Mercedes-Benz S class will lose 35 percent of its value after first year, while Model S loses only 25 percent. (Nelson 2014.) It will be seen with the production of Model 3, how well Tesla's older models hold their value.

No advertising

Tesla has no advertising, advertising agencies and no Chief Marketing Office. Tesla's new-technology based approach in automobile marketing shares some of the traits with Apple. (Mangram 2013.) "As with Apple, fascinated media do much of Tesla's PR, said Jeremy Anwyl, vice chairman of auto consultancy Edmunds.com" (McCarthy 2013). Mangram (2013) sees that "Tesla should focus much of its advertising efforts around specialist events and conferences on par with Apple's MacWorld Expo and the Apple Expo. These events typically draw a sizeable gathering of sales prospects and media representatives. These events must capture the hearts and minds of several key groups: its customers, its dedicated sales force, industry analysts and the press. By positioning itself as the first company to commercially produce an all-electric vehicle that is federally compliant and achieves a market-leading range on a single charge, Tesla has been successful in generating

significant media coverage of the company and its vehicles.”

Great examples of the “specialist events” Mangram describes are for example the Model S Beta Reveal in October 2011, Model X Unveiling Event in February 2012 and Tesla Model S P85D unveiling and test drive event in October 2014. All of the events are similar to the events of Apple: the events are hosted by Tesla CEO Musk, held at large halls with good lighting and music, people attend from the press and outside it and the technologies are presented in a lavish way.

The unveiling of Model S P85D especially received a lot of attention through the media. As the model is the fastest accelerating four-door production car of all time, Tesla decided to create a stage where people could sit into the car and be launched as fast as possible through a track. One participant of the press described it: “-- a course I think you can safely call the lap of terror. The first half involves accelerating through a tent that's been rigged with multicolor neon lights, resembling something like Rainbow Road from Mario Kart, albeit with a more real sense of death if something went wrong. The second half of the course demos some of the car's new "autopilot" features” (Lowensohn 2014). The event and the performance of the car sparked many videos throughout media where people show their reactions inside the car to the fast acceleration.

All of the external level services show that Tesla aims to separate itself from the business system of gasoline cars. It could have, like most gasoline car manufacturers do, used separately owned dealerships and service stations, tried to use an external producer for creating charging stations and used advertising for its EVs, but it decided to create a completely new business system for EVs. The effort needed to create a successful start-up car company is already a large undertaking, but Tesla seems willing to create most of the systemic innovating by themselves. With a visionary leader like Musk at the helm of Tesla as the leading company in EVs that beat gasoline cars on multiple performance levels, it seems fitting that Tesla aims to excel also in all other levels of systemic innovating.

5 CONCLUSION

The case of Tesla Motors' implications for theory

From the understanding of the case of Tesla Motors, this research contributes by connecting the two previously separated theories of disruptive and systemic innovation together. Systemic innovation is explained as an innovation that cannot succeed by its own merits and requires complementary innovations and adjustments to succeed (Maula et al. 2006). Originally disruptive innovation is seen in a way that it will ultimately capture the market after its primary performance dimension is advanced (Christensen 1997). For EV to function as a disruptive innovation and ultimately dominate the car market, it requires systemic innovating to do so. Therefore I suggest that EVs are a disruptive and a systemic innovation.

Maula et al. (2006) found that disruptive innovation differs from systemic innovation because of their resource allocation methods: disruptive innovation focuses only on the internal resource allocation of a company, but systemic innovation requires attention on external resources and actors that produce complementary innovations. Contrary to this view, I suggest that as EVs have both disruptive and systemic elements, they should have a focus on internal and external resource allocation on all levels. With Tesla Motors this can be explained by the disruptive technology of batteries: Tesla benefits also from external resources such as developer communities and related industries that are advancing lithium-ion batteries and cannot dominate the car market without it.

Chesbrough and Teece (1996) see that systemic innovation should be done within one company as to avoid arising conflicts. According to Maula et al. (2006) this method is infeasible “since even the largest companies lack the financial resources let alone technological and market capabilities to create the simultaneous complementary innovations necessary for successful systemic innovation”. Tesla has proven that systemic innovating can be done successfully on all levels by one company, but on the other hand it is also focused at embracing the whole business system of EVs and its external actors. This embracing of the business system can be explained by Tesla making its patents public in 2014, which promotes open innovation that Maula et al.

(2006) see as a requirement for successful systemic innovation. Therefore Tesla has proven that both methods of implementing systemic innovation are possible.

Maula et al. (2006) see that small and medium sized companies cannot act as leading companies to create architectures and this role should be implemented by larger incumbent companies. Nevertheless they see that future research could study whether this is possible. Tesla has proven it to be possible. In comparison to other car manufacturers, Tesla is a small company only focused in the production of the disruptive innovation of EVs. Nevertheless it has proven that it can create architectures, such as the Model S platform and the Supercharger stations, to steer systemic innovating. Through studying Tesla I believe that smaller companies and even individuals might often be more geared to understand and embrace the potential of new technologies and systems.

Implications for practice

The main implication for practice is the understanding of the complexities in relation to the advancement of EVs. All of the actors, such as incumbent companies, competitors and governments need to understand especially the leading company's efforts on all levels to make correct decisions regarding their own resource allocations to the business system. When competitors and incumbent companies see the full scale of complex systemic adjustments a leading company has achieved, it could be too late or extremely difficult to capture the same competitiveness the leading company has. With governments the comprehensive understanding of the business system will help in creating comprehensive policies to make especially the environmentally beneficial disruptive innovations more attractive.

In the context of systemic innovation, also the understanding of disruptive innovations should be increased. Maula et al. (2006) found that often disruptive innovation is seen as unappealing to incumbent companies because it underperforms on the main performance dimension that is mostly appreciated by consumers. Nevertheless if the disruptive innovation finds new performance dimensions and improves on some of the old ones, and if the main performance dimension can be increased through systemic innovating, the disruptive innovation could end up dominating the market. I believe this is what Tesla is about to do and much of it will

be tested with the launching of the mass market Model 3. Even though systemic innovation especially with a disruptive innovation requires a long-term view and massive investing, companies should understand that these innovations could have huge potential. Additionally effective systemic innovation could result in a complex competitive advantage that is hard to achieve by competitors, but this requires an understanding of new technologies and their business systems.

Limitations

As the theory of systemic innovation includes multiple sources of actors and their signals, in this research all of them could not be studied. Even though Tesla has created the most competitive disruptive innovation and implemented most of the systemic innovating, I could not study all of the advances even Tesla has made on these levels. Also all of the capabilities of Tesla could not be studied, but the understanding of Elon Musk as Tesla's CEO helped in understanding how the systemic innovating was implemented. In the end Tesla as a case validates and supports the creation of new theory that is the main contribution of this research. Furthermore the theory structure of this research supports the partly chosen data about Tesla.

Future research

Future research is required on systemic innovation. This research has found the line when an innovation can be seen as systemic to be unclear. EVs have proven to have such strong elements of disruptive and systemic innovation that I could not oversee the adjustments required on the business system of EVs to succeed as a disruptive innovation. On the other hand EVs are only one case in validating these findings so further research should focus on understanding systemic innovation better and to see if also other innovations have such strong systemic elements that they could be called systemic innovations. Additional focus could be to further study the relation between disruptive and systemic innovation.

Towards a sustainable future

Roadster proved in 2008 that an EV could compete against gasoline cars solely with its capabilities as a disruptive innovation and in 2012 Model S improved on these capabilities. With Tesla's additional systemic innovating efforts, EVs have become

increasingly competitive. Supercharger stations provide access to fast and free charging, battery swapping technology does charging faster than fueling and the battery Gigafactory aims to lower the price of EVs. If all of these advances will be executed as Tesla is planning to, EVs will have superior design architecture and competitive enough charging and pricing to take gasoline cars head on.

Lastly the heroic role of Elon Musk should not be overseen. Early on with his career he envisioned that all transportation would become electric. With Tesla his goal is not to be profitable, but to transform the world towards sustainable energy and transportation. Clearly established, hierarchic and bureaucratic companies are not the answer for creating new business systems for important disruptive innovations. We need more visionary and philanthropic individuals who understand technologies, systems and the common good in shifting us towards a brighter future.

“Who controls the past controls the future. Who controls the present controls the past”, George Orwell.

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